THE JOURNAL OF
PROSTHETIC
DENTISTRY

## *CONTENTS FOR MAY-JUNE, 1960*

**Through the Eyes of the Editor.**
Carl O. Boucher, D.D.S., The Ohio State University, College of Dentistry, Columbus, Ohio ..... **401**

**COMPLETE DENTURES**

**A Relining Technique for Mandibular Dentures.**
Robert R. Gillis, D.D.S., St. Petersburg, Fla. ..... **405**
*A practical technique for refitting the impression surface of mandibular complete dentures and restoring jaw relations and occlusion.*

**The Current Status of Prosthodontics.**
Carl O. Boucher, D.D.S., The Ohio State University, College of Dentistry, Columbus, Ohio ..... **411**
*The progress made in the various facets of complete denture service is evaluated, and some of the areas needing further research are pointed out.*

**The Extraoral Tracing as an Aid in Tooth Selection.**
W. D. Pearson, D.D.S., Chattanooga, Tenn. ..... **426**
*Extraoral needle-point tracings are used to determine the type of posterior tooth to be used. Zero-degree teeth are used for patients who have poor muscular coordination as indicated by their difficulty in making the tracings.*

**The Mandibular Hinge Axis and a Method of Locating It.**
B. B. McCollum, D.D.S., Sepulveda, Calif. ..... **428**
*The location of the hinge axis is essential to the ultimate possibilities in the development of a harmonious dental occlusion. It is an aid in recording some other important jaw relations.*

**Hinge Axes. Part I. The Transverse Hinge Axis.**
Don N. Brotman, D.D.S., Baltimore, Md. ..... **436**
*The transverse hinge axis of the mandible is defined and explained. The technique for its location is described and its use as a means for checking centric relation mountings is suggested.*

**Registration of the Condyle Path Inclination by Intraoral Wax Records: Variations in Three Instruments.**
Ulf Posselt, L.D.S., Odont. Dr., and Göran Franzén, L.D.S., M.K., The Royal Dental School, Malmö, Sweden ..... **441**
*Variations in the condylar guidance element adjustments of different articulators are demonstrated. These differences are due mainly to the interocclusal wax recording technique and the amount of protrusion at which the registration is made.*

(*Continued on page 3*)

# *"POLIDENT-CLEAN"* dentures pass the test of personal proximity

*reflecting credit upon your skill*

Patients appreciate your recommendation of Polident for cleaning dentures the safe, easy way. Polident floats away debris, removes stains—leaves dentures fresh, sparkling, odor-free and pleasant to wear. Its gentle soak and rinse action won't mar the lustrous finish and delicate detail which are evidence of your professional skill. Recommend Polident to all your denture patients.

*recommended by more dentists than any other denture cleanser*

**POLIDENT®**

*For office supply of samples, write*

BLOCK DRUG COMPANY, INC.

105 Academy Street, JERSEY CITY 2, N.J.

**A Complete Denture Technique for Selecting and Setting up Teeth.**

Lucian G. Coble, D.D.S., Greensboro, N. C. ..... **455**

*A description of the technique for using the equipment designed by the author.*

**Physical Factors Related to Denture Retention.**

R. G. Craig, Ph.D., G. C. Berry, M.S., and F. A. Peyton, D.Sc., University of Michigan, School of Dentistry, Ann Arbor, Mich. ..... **459**

*Capillary attraction is shown to be a major retentive force for dentures. A thin film of saliva is essential to the operation of this force.*

**The Role of Learning in Denture Retention.**

N. Brill, L.D.S., G. Tryde, L.D.S., and S. Schübeler, L.D.S., Royal Dental College, Copenhagen, Denmark ..... **468**

*The relative ability of patients to wear dentures varies with age and neuromuscular control. Clinical tests are reported to show the importance of learning to the retention of dentures.*

**Tests of Balanced and Nonbalanced Occlusions.**

Vincent R. Trapozzano, D.D.S., St. Petersburg, Fla. ..... **476**

*A comparative study of the chewing efficiency and the reactions of 12 patients to occlusions balanced only in centric position with those balanced in eccentric occlusal positions as well.*

**Discussion of "Tests of Balanced and Nonbalanced Occlusions."**

S. Howard Payne, D.D.S., University of Buffalo, School of Dentistry, Buffalo, N. Y. .. **488**

**Trouble Shooting in Complete Denture Prosthesis. Part IV. Proper Adjustment Procedures.**

Joseph S. Landa, D.D.S., New York, N. Y. ..... **490**

*An orderly and logical system for diagnosing and correcting denture difficulties is suggested.*

**Medical Significance of Equilibration of the Masticating Mechanism.**

Herbert T. Kelly, M.D., and David J. Goodfriend, D.D.S., Philadelphia, Pa. ..... **496**

*A discussion of the etiology, diagnosis, and treatment of temporomandibular joint disturbances which may occur as the result of faulty occlusion. A team of medical specialists and dentists is recommended, but dentists are in a position to detect the occlusal disharmony and treat it to avoid serious consequences.*

**Physical Properties of Denture-Base Materials.**

John A. Cornell, B.S., M.S., John L. Tucker, B.S., and Catherine M. Powers, Philadelphia, Pa. ..... **516**

*The resistance of various types of denture-base materials to breakage upon impact is reported.*

**FIXED PARTIAL DENTURES**

**Factors That Affect the Accuracy and Dimensional Stability of the Mercaptan Rubber-Base Impression Materials.**

G. E. Myers, D.D.S., M.S., F.D.S., and D. G. Stockman, A.B., D.D.S, University of Michigan, School of Dentistry, Ann Arbor, Mich. ..... **525**

*Research on the effect of various methods of handling elastic impression materials is reported. The results provide a check list for clinical difficulties in the use of these materials.*

**The Forces That Oppose the Withdrawal of Impressions.**

Dioracy Fonterrada Vieira, C.D., São Paulo, Brazil ..... **536**

*An analysis of the forces that are involved in removing impressions from teeth and cavity preparations. These forces are important when their relationship to the distortion of impressions is considered.*

*(Continued on page 5)*

# NEW! REVOLUTIONARY!

## VACUUM-FIRED ACRYLIC RESTORATIONS

## AN EXCLUSIVE NU-DENT PROCESS! (pat. pend.)

**NU-DENT is happy to announce a new, revolutionary development — Vacuum-Firing of ACRYLIC restorations.**

**Now . . . *for the first time*, it is possible to obtain the *advantages* of curing under dry heat and vacuum . . . to achieve greater impact strength, greater crushing strength, greater resistance to abrasion . . . plus porcelain-like lustre and beauty in *acrylic restorations!***

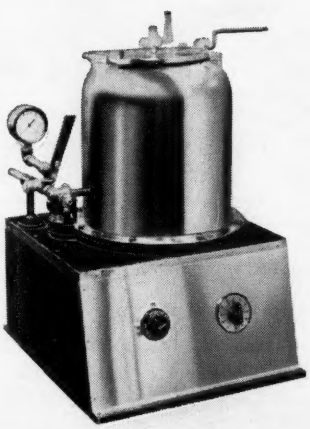
**It took 4 years of intensive research . . . 2 years of clinical experimentation . . . to develop NU-DENT'S exclusive *Acrylic Vacuum Furnaces* and the exclusive technique required. Vacuum-Fired Acrylic Restorations introduce an entirely new esthetic and functional concept in acrylic jackets, veneers, bridges, etc. . . .**

**They possess a truly porcelain-like glaze** . . . nature-rivalling lustre never before available in such restorations.

**Greater Impact Strength . . . Greater Crushing Strength.** Vacuum-Fired Acrylic Restorations possess greater surface hardness. But there is no brittleness, because the sub-surface acrylic is left resilient to absorb stress and sudden shock.

**Greater Color Stability.** Under Vacuum-Firing, the release of excess monomer is carefully controlled, thus eliminating color changes and assuring exceptional color stability.

Mail the coupon for detailed information on Vacuum-Fired Acrylic Restorations and on **Exelon**... Nu-Dent's new, completely different opaquing material. **Exelon** forms a porcelain-like molecular bond to the gold and also to the acrylic. **Exelon** adheres with amazing tenacity . . . There is no possibility of flaking away or drawing away from the gold.



**nu-dent PORCELAIN STUDIO, INC.**
(Reg. U.S. Pat. Off.)
220 West 42 St., N.Y. 36, N.Y. • Phone—LA 4-3591, 2, 3, 4, 5, 6
9615 Brighton Way, Beverly Hills, Cal., Phone—CRestview 5-8717

(Send to NU-DENT Studio Nearest You)
**NU-DENT PORCELAIN STUDIO, Inc.**

Yes, I would like to find out more about Vacuum-Fired Acrylic Restorations as practice builders.

Dr._____

Address_____

City & Zone_____ State_____

**A Direct-Indirect Technique for Individual Gold Crowns.**

Frank N. Ellis, Commander (DC) USN, San Diego, Calif. ..... **545**

*A description of both the mouth and laboratory phases of the construction of full gold crowns with acrylic resin facings.*

**Why Dental Restorations Should Have Cusps.**

Charles E. Stuart, D.D.S., Ventura, Calif. ..... **553**

*A discussion of the ideal relationships between the cusps of posterior teeth and the cusped teeth. They must be mutually protective in order that the periodontal structures and temporomandibular joints will not be subjected to unnecessary strain.*

**The Cuspids as Substitutes for the Incisal Guide Pin.**

W. G. F. Schmidt, D.D.S., Chicago, Ill. ..... **556**

*The cuspids are used to provide the anterior guide to jaw movement. This allows free lateral movement without excessive balancing contacts.*

**OPERATIVE DENTISTRY**

**Practical Application of Current Casting Research.**

William J. O'Brien, B.S., New York, N. Y. ..... **558**

*The information obtained from research by many people on all factors involved in making dental castings is translated into simple guides to better castings.*

**Class V Restorations.**

John H. Mosteller, D.D.S., Mobile, Ala. ..... **561**

*A discussion of the relative merits of different filling materials for Class V cavities. Gold foil is found to be superior to the others, and a detailed technique for its use is described.*

**Ultra-Speed and Auxiliary Equipment in Fixed Partial Denture Construction.**

H. C. Kilpatrick, D.D.S., New Canaan, Conn. ..... **574**

*The use of a multiple arrangement of equipment of various rotational speeds has advantages to both the patient and the dentist. The proper choice of rotational speed for each operation is essential to maximum efficiency and comfort.*

**A New Vibrator for Amalgam Condensation and Removal of Calculus.**

Sam Karlström, Odont. Dr., Gävle, Sweden ..... **586**

*The Inka vibrator, which may be attached to a dental handpiece, is described and its care and use are discussed. Some points are shaped so they can condense amalgam in cavities, and others may be used for removing calculus.*

**MISCELLANEOUS**

**Care of Dentures.**

Louis M. Fleisch, D.D.S., Topeka Kan. ..... **591**

**Readers' Round Table** ..... **592**

**Book Reviews** ..... **593**

**News and Notes** ..... **595**

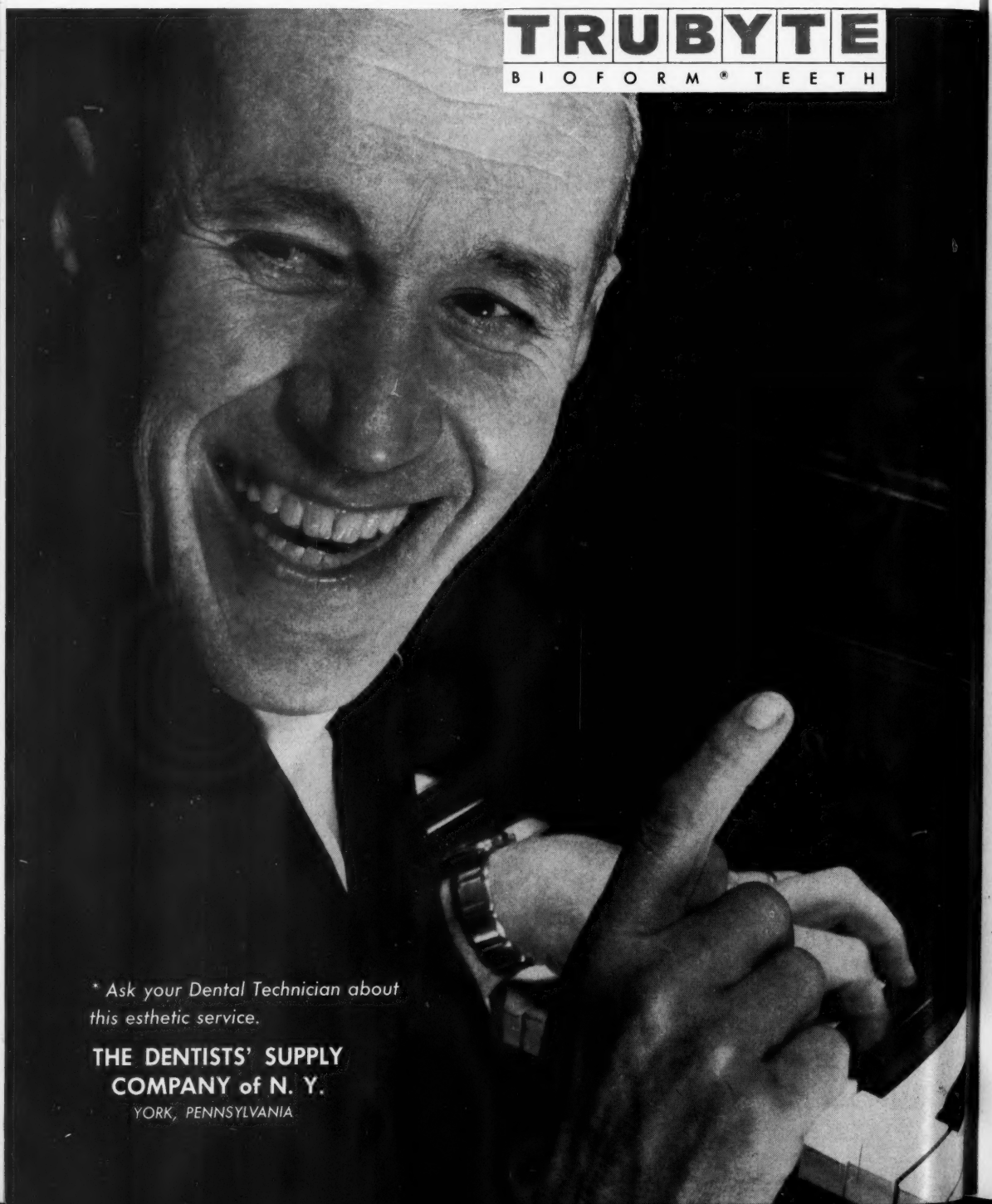
**Directory** ..... **600**

Vol. 10, No. 3, May-June, 1960. Journal of Prosthetic Dentistry is published by the C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription rates: United States and Its Possessions $12.00, Students $6.00; Canada, Latin-America, and Spain $12.50, Students $6.50; Other Countries $13.00, Students $7.00. Single copies, $2.50 postpaid. Second class postage paid at St. Louis, Mo., and at additional offices. Printed in the U. S. A. Copyright © 1960 by the C. V. Mosby Co.

# *a four-harmonies denture...**

Dentists everywhere are "harmonizing"—they're harmonizing tooth form, size, color and arrangement to provide their patients with naturally beautiful Trubyte Bioform Esthetic Dentures, like the one illustrated here. All together now . . . one, two, three, four . . . harmonies!

*Essential to finest esthetic results . . .*




* *Ask your Dental Technician about this esthetic service.*

**THE DENTISTS' SUPPLY COMPANY of N. Y.**

*YORK, PENNSYLVANIA*

THE JOURNAL OF
PROSTHETIC
DENTISTRY

MAY-JUNE
1960
VOLUME 10
NUMBER 3

## THROUGH THE EYES OF THE EDITOR

Robert R. Gillis describes his techniques for relining complete mandibular dentures. The procedure is applicable when the maxillary denture is in its correct position and when the errors in occlusion are the result of lower ridge resorption. The vertical and horizontal relations of the casts are established by records made in the mouth at the time the impression is made. The lower denture is repositioned on the articulator into its correct relation with the new cast and the upper teeth. This procedure should not be expected to correct errors that were built into dentures when they were made.

Carl O. Boucher discusses the current status of prosthodontics with the idea of establishing areas of agreement and disagreement. He points out what he believes to be some misconceptions and makes some suggestions regarding attitudes, definitions, concepts, techniques, and unsolved problems. This article is a subjective analysis and others may make different interpretations, but until such a time that all questions can be answered on the basis of fact, rather than by combinations of facts and opinions, any evaluation must be subjective.

W. D. Pearson classifies his patients according to the type of extraoral needle-point tracings they make. One tracing with a minimum of directions is made by the patient. It is compared with a tracing made with directions that should produce a sharp tracing with narrow arcs. This would seem to be a method for locating the "functional centric occlusal area." His recommendations that cusped teeth should be used for patients who made a sharp tracing easily and that zero-degree teeth be used for other patients merit further study and observation.

B. B. McCollum discusses the mandibular hinge axis and its significance to dentistry. He cites some of the history and controversy about the hinge axis and gives his interpretation of the anatomy and physiology involved. He describes his experiments relating to jaw position and jaw movement. The key to successful location of the hinge axis was the rigid attachment of the face-bow to the mandible by means of a "clutch" on the teeth and a central bearing point to eliminate cuspal guidances. This observation emphasizes the necessity for separating centric occlusion from centric relation in our thinking. The centric relation must be recorded; then the centric occlusion may be built in harmony with it. His statement that ". . . whenever the articulation or occlusion of the teeth did not conform to my definition of the centric relation (the most retruded position of the idle mandible), there was the characteristic untoward result" is significant. If the location of the hinge axis is an accurate means for locating the centric relation, its value cannot be questioned.

Don N. Brotman discusses the transverse hinge axis in the first of a series of articles on the hinge axes of the mandible. He points out certain conflicting concepts regarding it. His definition of the transverse hinge axis is remarkably similar to some definitions of centric

relation. He uses the transverse hinge axis determination as a means for checking the accuracy of the relations of casts mounted on the articulator (in what some others call centric relation). This varies somewhat from the use that others make of the transverse hinge axis.

Ulf Posselt and Göran Franzén report their investigations of condylar guidance adjustments on different articulators. Wax interocclusal records were used by five dentists ("readers"), and the results of records made with different amounts of protrusion were compared. The variations were attributed to two main factors—the recording medium and the structure of the mandibular fossae. The results indicate that only conservative conclusions should be drawn from a comparison of eccentric interocclusal records. The mechanical factors indicate that a large amount of protrusion is desirable, but an amount of protrusion to bring the incisors end to end would be more nearly physiologically correct.

Lucian G. Coble describes his technique for mounting casts and arranging teeth on his articulator. Phonetics are used for determining the vertical jaw relations and an intraoral tracing made by a central bearing point is used to determine the horizontal jaw relations. The system of tooth arrangement seems to place greater emphasis on mechanical factors than on esthetic factors. No doubt the positions of individual anterior teeth could be altered after the basic positions are established. This type of variation would make the dentures appear more natural.

R. G. Craig, G. C. Berry, and F. A. Peyton discuss the physical factors related to denture retention and report their experiments on the effectiveness of capillary forces. Their results indicate that these forces are the principal factor in retention. This means that intimacy of contact of the denture base with the mucous membrane is essential. However, other conditions, such as occlusal disharmony or an improperly shaped external form of dentures, can reduce the capillary forces by moving the dentures out of their correct positions.

N. Brill, G. Tryde, and S. Schübeler classify complete denture patients according to their "responses" to dentures. It is an interesting classification which points out a source of error in clinical research and in clinical evaluations of "success" in denture service. The relative ability of patients to *learn* to use dentures cannot be ignored. The age of the patient is a factor affecting the response to dentures, but the suggestion that preventive dentistry "has created a problem it cannot solve" is open to serious question. While a young person is likely to have success with dentures *at first,* he becomes an older person in time. Dentures made 20, 30, or 40 years later (and placed on deteriorated foundations) will require additional learning at a time when the ability to learn is decreased. The *cumulative* difficulties involved in wearing dentures would seem to be greater than the *postponed* difficulties. This is, of course, provided that the preventive measures are effective in maintaining reasonable health of the supporting bone. Excessive uncontrolled periodontal disease must not be tolerated just to postpone the wearing of dentures.

Vincent R. Trapozzano reports his tests of the effectiveness of and the patients' reactions to dentures with different occlusions. He made dentures for 12 patients in such a way that the occlusions could be changed on the same denture bases. In each instance, one occlusion was balanced in all positions and the other occlusion was balanced only in centric position. The results indicated that some patients preferred one type of occlusion and others preferred the other type. He states: "Because of the limited number of patients tested, this study was neither intended to nor does it give the complete answer to this question." It is difficult to eliminate all of the variables other than the one being tested in a study such as this. The common bases on which the occlusions were built do eliminate one variable, but other factors, such as the history of denture wearing experience, the ability of the patients to learn to accommodate their eating habits to dentures, etc., cannot be controlled in a clinical test. Perhaps similar tests would show different results if the patients were changing from natural dentitions to artificial dentures for the first time. The facts that 10 of his patients "*adapted* their mandibular movements to the lack of free movements in eccentric positions during function" and that 9 chewed more efficiently with the completely balanced occlusion seem significant. It should be noted that, while he classes the occlusions as "balanced" and "nonbalanced," *all* of the occlusions were balanced in centric position.

Joseph S. Landa suggests orderly and logical procedures in making diagnoses for adjustments of dentures. If some such system is not used, errors will be made and otherwise good dentures will be damaged. Denture adjustments must be made only after an adequate diagnosis of the difficulties and their causes. The simple procedure of grinding from a denture at the spot indicated by the patient is inadequate and unprofessional service. Accurate adjustments on dentures require all of the skill, knowledge, and ability at the dentist's disposal.

Herbert T. Kelly and David J. Goodfriend discuss the medical significance of the equilibration of the masticating mechanism. They report a 6-year study of the relationships between occlusion and the temporomandibular joints to vertigo and other severe symptoms of temporomandibular joint disturbances. They found that a high percentage of patients with these symptoms were relieved by equilibration of the occlusion coordinated with psychosomatic treatment. They discuss the causes of the symptoms by relating them to the anatomy and physiology of the temporomandibular joints and describe both the medical and the dental diagnostic procedures. They conclude from their studies of 102 patients that cooperation between the dentists and the physicians is essential to successful treatment of these disorders. Dentists can detect the possibility of occlusal disharmony and treat it, but many patients will require medical or psychosomatic treatment as well. It is important that dentists understand the mechanics of traumatic forces that *could* cause damage to the joints.

John A. Cornell, John L. Tucker, and Catherine M. Powers report their studies of the physical properties of denture-base materials. They used a falling ball impact test on different types of base materials under varying conditions. They conclude that crosslinking improves the impact strength of these materials, while moisture, plasticizers, and filled compositions have decreased resistance to impact. From their results, it appears that the addition of some "reinforcing" materials is not effective.

G. E. Myers and D. G. Stockman report that the mercaptan rubber-base impression materials and the clinical techniques for their use have been improved greatly in the past 6 years. They also report their research on the various factors that affect the accuracy of these materials. The test methods were devised to be as near to situations of practical use as possible. Their conclusions provide a check list which could serve as a guide to the most effective use of these materials.

Dioracy Fonterrada Vieira discusses the forces that resist the removal of impressions from teeth and cavity preparations. Several kinds of forces are involved, and it is apparent that they can cause clinical failures if proper consideration is not given to them. He points out the importance of the use of materials with favorable physical properties and techniques which conform to the limitations of the materials.

Frank N. Ellis describes his technique for making full gold crowns with acrylic resin facings. The procedure establishes the occlusion of the wax pattern in the mouth, while the contour of the buccal and labial surfaces is developed on the die. No casts or interocclusal records are necessary in the technique.

Charles E. Stuart discusses the restoration of natural teeth so they will protect both the periodontal structures and the temporomandibular joints from damage. He uses the lingual inclines of the upper cuspids to guide the development of the form of posterior cusps in wax. Then, the finished restorations on the posterior teeth and the cuspids serve to protect each other. He emphasizes the importance of building centric occlusion to coincide with the posterior terminal hinge position (centric relation). The limitation placed on lateral jaw movement has merit for natural teeth, but a "cuspid-protected occlusion" on complete dentures could be disastrous to the stability of tissue-supported dentures. The reason is that a rotating force would be applied on complete dentures when only contacts between two cuspids on one side existed. The rotation of either denture would reduce the retentive forces of the denture. The problem is different with natural teeth in the mouth.

W. G. F. Schmidt depends on the contacts between cuspid teeth for the anterior guidances of teeth in the mouth. He compares these contacts with the incisal guidance on an articulator. The functions of these elements could be similar. He points out the dangers of excessive balancing contacts. With natural teeth, temporomandibular joint disturbances

could be the result; with complete dentures, soreness of the supporting tissues and looseness of the dentures could result.

William J. O'Brien summarizes recent casting research and points out the means by which the results can be put to use in routine practice. He specifies definite sprue sizes, sprue lengths, burnout temperatures, investing procedures, and other factors which will improve the quality of dental castings.

John H. Mosteller compares the effectiveness of various materials for making Class V fillings. He concludes that gold foil is the material of choice and describes, in detail, his technique for cavity preparation and for placing these fillings. It is an orderly, well-planned technique, and it should be effective if it is carried out with meticulous care.

H. C. Kilpatrick discusses the use and arrangement of various types of auxiliary equipment for fixed partial denture procedures. The wide range of types of equipment available today requires careful analysis by each dentist in order to select those items which would be of the greatest value in his office. He illustrates the mechanics of instrumentation by describing the procedures, instruments, and rotational speeds he uses for making a fixed partial denture. He points out the importance of using the most effective instrument for each operation. He also reports his measurements of the rotational speeds of the cutting instruments. These are shown to be quite different in use than when running idle.

Sam Karlström describes a vibrator with interchangeable working points which can be used to condense amalgam in cavities or to remove calculus from teeth. The instrument provides "soft" vibrations for maximum comfort to the patient while silver alloy is being condensed. The points may be adjusted to reach any position in the mouth.

*—Carl O. Boucher*

## *COMPLETE DENTURES*

# A RELINING TECHNIQUE FOR MANDIBULAR DENTURES

ROBERT R. GILLIS, D.D.S.
*St. Petersburg, Fla.*

THE RELINING OR REBASING of a mandibular denture is a simple problem when alveolar atrophy has progressed to such an extent that the originally built occlusion has been lost. Yet, many dentists hesitate or refuse to reline such dentures and recommend and construct new dentures for the patient. We cannot deny that making new dentures is probably more to the dentist's economic advantage; however, this need not be so, because the technique to be described compensates the dentist equally well for the time spent and provides considerable financial advantage for the patient.

### DIAGNOSIS

When dentures have been worn for too long a time without service, one or more of the following conditions may be noted:

1. There may be considerable loss of ridge tissue under the dentures.
2. The chin may approach the nose too closely.
3. The chin may be in an apparently protruded position at the occlusal contact where it is stopped in its upward and forward arc of closure.
4. The teeth of the mandibular denture may have "jumped over" the corresponding upper teeth, and the lower incisors may be in front of the upper incisors.
5. The maxillary denture may be "thrust forward" by every closure into occlusal contact.
6. The denture space in the patient's mouth may be collapsed or distorted.

These conditions are at variance with the eight essential conditions for successful denture service. Four of these conditions are supplied by the patients:

1. The ridge form, which is recorded by the impression technique.
2. The ridge relation, which is recorded by registering the denture space.
3. The condylar guidances, which are recorded by eccentric interocclusal records.

---

Read before the Congreso Panamericano, Asociación Dental Mexicana, and the Indiana State Dental Association.

4. The "realeff" (resiliency and like effect), which involves the quality of the saliva, unequal resilient areas, etc.

The other four conditions are determined by the dentist:

5. The form and color of the teeth.
6. The cusp form.
7. The incisal guidance.
8. The compensating curves in the arrangement of the teeth.[1,2]

Many dentures are made without adequate observance of the ridge relation, the condylar guidances, the incisal guidances, and the compensating curves. Neglect or failure to apply these four factors correctly can cause traumatic injury which produces ridge atrophy.

The technique for relining dentures to be described applies particularly to the patient whose mandibular ridge has been reduced (shortened) 2 mm. or more and in whom the resulting malocclusion is such that the centric relation and centric occlusion are both lost (see Fig. 2). Making a new impression in the original base can establish a new ridge form, but it does not restore either centric relation or centric occlusion. Both of these relationships are essential to comfort and efficiency.

## VERTICAL DIMENSION OF REST POSITION

The first step is determination of the proper vertical dimension of rest position. I depend wholly upon the functions of speech and swallowing in determining this position.

This technique is predicated upon the newer concept of the muscles that make up the "muscles of mastication." All of the muscles of the head and neck play a role in positioning the head for efficient mastication, and all of the muscles of expression contribute controls in mastication.[3]

The vertical dimension of rest position is that relation of the mandible to the maxillae measured and recorded when *all* of the muscles of the face and neck are in a state of balanced equilibrium.[4,5] There are some dentists who believe that the vertical dimension of rest position shortens with advanced age. From observations and records spanning more than 40 years, I hold that this position does not change after young adulthood (Fig. 1).

## VERTICAL DIMENSION OF OCCLUSION

The vertical dimension of occlusion is determined after ascertaining the vertical dimension of rest position by the use of homomuscular functions employing *all* of the muscles of the face and neck. I avoid the use of directions to the patient to "bite," "close," or "shut your teeth together." These directives will be accompanied almost invariably with voluntary effort by the patient, *and error will be incorporated in the registration* to whatever degree voluntary effort is used.

Having determined and recorded the vertical dimension of rest position, the resulting interocclusal distance is observed. Softened modeling compound is luted to the occlusal surfaces of the mandibular bicuspids and molars and resoftened in hot water. The dentures are placed in the mouth and the patient is directed to say, *"m-m-m-m";* he continues saying *m,* doing nothing else. The cusp forms of the

upper artificial teeth will register in the soft modeling compound (the upper denture can be stabilized with adhesive powder). The resulting record is removed from the mouth, chilled, and any excess modeling compound is removed, leaving only an impression of the cusps. The mandibular movement made in saying *m* registers a closure from the vertical dimension of rest position but does not establish the vertical dimension of occlusion.

The modeling compound is heated again, the dentures are reseated in the mouth, and the patient is instructed to "smile, grin, *grin hard,* and swallow; hold thus and keep on grinning." The action of grinning retracts the mandible to centric relation, and swallowing produces a closing movement which stops at the

Fig. 1.—Pictures of a patient from age 12 to age 67 years. There is no change in the vertical dimension of rest position after young adulthood even though dentures were worn during the last 30 years.

vertical dimension of occlusion. The excess modeling compound is removed, and if necessary, the "grin-swallow" procedure is repeated. The vertical dimension of occlusion usually measures about 3.5 mm. shorter than the vertical dimension of rest position. However, the amount of interocclusal distance is an individual measurement for each patient and may be less or more than the 3.5 mm. average.

The grin-swallow procedure is repeated with the modeling compound hardened to determine if the cusps interdigitate correctly in the compound when the patient swallows.

## INITIAL IMPRESSION

A lower wash impression is made in the old denture base after the vertical dimension of occlusion has been established. The denture containing the impression

Fig. 2.

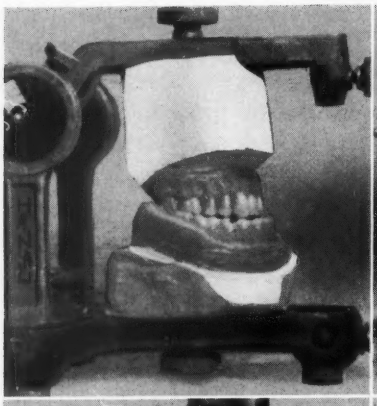


Fig. 3.

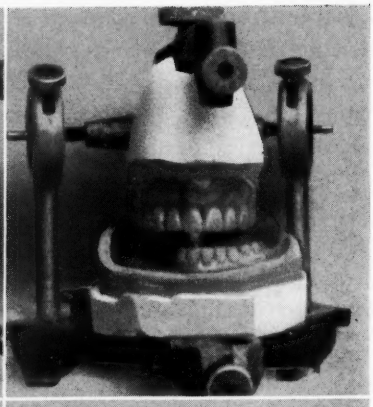


Fig. 4.

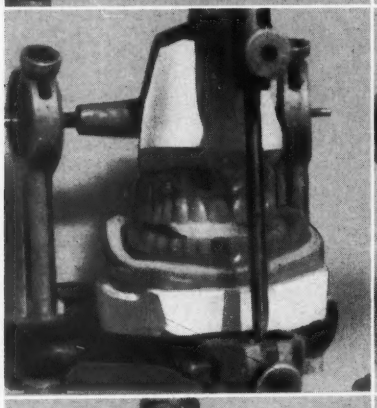


Fig. 5.

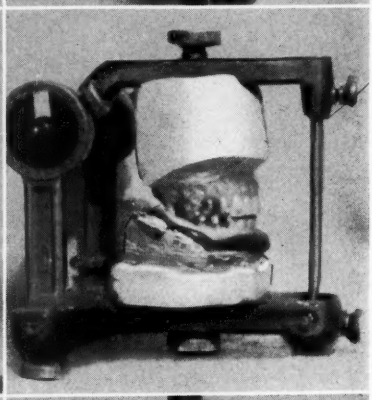


Fig. 6.

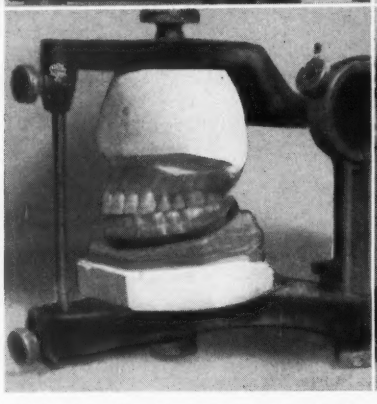


Fig. 7.

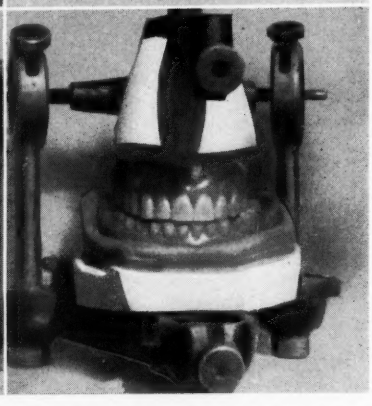


Fig. 2.—The vertical dimension of occlusion has closed because of resorption of the ridge. The lower anterior teeth are in front of the upper anterior teeth, as a result of the tremendous change in the vertical dimension.

Fig. 3.—Modeling compound is added to the occlusal surfaces of the lower molars and bicuspids. The correct jaw relations are established by the homomuscular functions of speech, smiling, and swallowing.

Fig. 4.—The space between the teeth indicates the closure of the vertical dimension of occlusion since the dentures were originally constructed.

Fig. 5.—The lower denture is attached to the upper denture with the teeth in the original centric occlusion.

Fig. 6.—The excess modeling compound is removed, and the denture is ready for the final wash impression.

Fig. 7.—The relined denture restores centric occlusion at centric relation and re-establishes the correct vertical dimension of occlusion.

material is placed in the mouth and the grin-swallow routine is followed. The upper cusps again reseat into the indentations; while the impression material is still workable, the patient continues to grin, pout, and swallow while maintaining occlusion, and thus the border is molded for a functional, closed-mouth impression.

## LABORATORY PROCEDURES

A cast is poured in the lower impression and in the upper denture. The two dentures are mounted on an articulator that has an incisal pin to maintain the established vertical dimension of occlusion. The thickness of the modeling compound in the molar-bicuspid region indicates the amount of vertical dimension that has been lost since the dentures were first constructed (Fig. 3). The incisal pin position must be maintained to present this measurement.

The modeling compound is removed from the lower teeth. The space between the upper and lower teeth is also evidence of the amount of ridge resorption (Fig. 4).

The lower denture is removed from the cast, and the lower cast is covered with tin foil, smoothly but loosely. The lower denture is attached to the upper denture in the occlusal relationship as indicated by the intercuspation of the molar-bicuspid teeth. This position restores the occlusion that was built into the dentures originally. The flanges of the denture may require some shortening to permit the articulator to close to the desired position.

The vertical space that did show interocclusally is now between the lower denture and the lower cast. Softened modeling compound is added to the lower cast covered with tin foil, and the lower denture is forced into the compound by closing the articulator to its fixed position (Fig. 5).

## FINAL IMPRESSION

After chilling the modeling compound, the lower denture together with the compound and tin foil are lifted from the cast. The excess modeling compound is trimmed away (Fig. 6), and the final wash impression is made in the patient's mouth using the grin-swallow-hold procedures. The cast is poured and the denture is processed (Fig. 7).

## SUMMARY

A relining technique has been described that permits the restoration of the proper vertical dimension of occlusion and also the centric occlusion that was originally built into the dentures. This technique has been used successfully for many patients, and from 2 to 14 mm. of lost vertical dimension (measured at the incisors) can be restored in a single procedure. The muscles are permitted to freely dictate maxillomandibular relations, and there is no need to be concerned about the "hinge axis" or "temporomandibular joint relations" when this technique is employed.

This technique is *not* applicable to dentures made with plastic teeth which have become grossly abraded; neither can this procedure correct faulty occlusion that was built into the dentures or other errors or omissions of original construction.

REFERENCES

1. Gillis, R. R.: Determination and Registration of the Denture Space, J. Ohio D. Soc. **21**:123-131, 1947.
2. Gillis, R. R.: The Denture Space and Its Registration in Full Denture Construction, Fort. Rev. Chicago D. Soc. **11**:5-10, 1946.
3. Thompson, J. R., and Brodie, A. G.: Factors in the Position of the Mandible, J.A.D.A. **29**:925-941, 1942.
4. Thompson, J. R.: The Rest Position of the Mandible and Its Significance to Dental Science, J.A.D.A. **33**:151-180, 1946.
5. Niswonger, M. E.: The Rest Position of the Mandible, and the Centric Relation, J.A.D.A. **21**:1572-1582, 1934.
6. Gillis, R. R.: A Method for Immediate Denture Service, J.N.D.A. **8**:667-674, 1920.
7. Gillis, R. R.: Establishing Vertical Dimension, J.A.D.A. **28**:430, 1941.

5462 Central Ave.
St. Petersburg 7, Fla.

# THE CURRENT STATUS OF PROSTHODONTICS

CARL O. BOUCHER, D.D.S.*
*The Ohio State University, College of Dentistry, Columbus, Ohio*

EACH DENTIST makes a subconscious evaluation of the current status of prosthodontics whenever he treats an edentulous patient. His evaluation is based upon the articles he has read, the lectures he has heard, the discussions he has participated in, the experiences he has had in the treatment of other patients, and the problems he faces in the treatment of the patient who is seeking his services at the moment. Therefore, his evaluation is valid only to the extent of these activities. If he does not read about, listen to, and participate in discussions of the problems relating to complete denture service, he must depend solely upon his experiences in the treatment of his own patients for his evaluation of the current status of prosthodontics.

## SUCCESS OR FAILURE

These experiences may be satisfactory to the dentist whether or not they are satisfactory to his patients. This is possible because of the nature of the current practice of prosthodontics. Each dentist determines the needs of his patients, plans the treatment, makes the impressions and jaw relation records, works out the problems in esthetics, fabricates the dentures (or has it done for him), inserts the dentures, and then becomes the sole judge of the effectiveness of his treatment. Too often, the dentist does not have the facts necessary to determine the success or failure of his treatment. He might not be aware of the possibilities there would have been *if* other procedures had been used.

If the patients do not complain too much, the judgment of the dentist is that the treatment was successful, regardless of the degree of efficiency of the restorations. Patients have no means for knowing whether the dentures are as good as they could be or not. Certainly, many patients are wearing dentures that are not as efficient or good-looking as they could be, simply because these patients do not know that they could have anything better. Consequently, they do not complain too much, and the dentist rates the treatment as being successful.

Other patients leave their dentists with the idea that the treatment which had been rendered was successful by seeking the services of other dentists. These patients may accumulate many dentures in their efforts to find the kind of service they *think* they should have. At the same time, they may leave a trail of dentists who are

---

Read before the Academy of Denture Prosthetics, Louisville, Ky.
*Professor and Chairman of the Division of Prosthodontics.

satisfied that they have succeeded where the others have failed. In these instances, each dentist may say to himself (or his assistant), "How could those other dentists have made such poor dentures?" He may not know that the next dentist to make dentures for the patient is including *him* in the list of dentists who make "unsuccessful" dentures.

Two things become apparent. First, there are no fixed standards which may be applied universally for judging denture service. Second, any evaluation of the current status of prosthodontics is of doubtful value because of the lack of information about what may be possible in the future. If we were attempting to send a rocket to the moon, we could measure the results of each attempt. Since we do not know the possibilities and limitations of the ultimate in denture service, we cannot be so precise.

The problem of evaluation is further complicated by the variations in mouth conditions which dentists must treat. The age, health, coordination, adaptability, and attitude of patients will vary greatly, and these factors may be more important to successful treatment by dentures than the mechanical and purely physical factors involved. All of us have seen patients wearing dentures that are "ill-fitting" from every standpoint but wearing them without complaint. These dentures may lack retention and stability, they may disfigure the face and interfere with speech, and their occlusion may be unbalanced in every jaw position (even to the extent that the upper denture of one set is used against the lower denture of another set). Are these to be considered as successful dentures just because the patients wear them without complaint?

On the other hand, we have seen patients who complain about dentures that look good, have good retention, stability, and occlusion, and are obviously well-made and well-fitted dentures. Patients cannot judge whether or not the dentures are as efficient as they could be. They can only report their own reactions to them, and this is hardly a scientific basis for an evaluation of prosthodontic service.

Therefore, this discussion is necessarily a subjective evaluation. The same limitations apply to the evaluations of the various *factors* involved in denture construction. It is to be hoped that the work of the Academy of Denture Prosthetics on statements regarding Principles, Concepts, and Practices in Prosthodontics will result, eventually, in a means for rating the validity of concepts and the effectiveness of prosthodontic techniques. This work must be a continuing operation conducted and carried out by men with minds open to the ideas of others. A stubborn adherence to ideas that have been "accepted through the years" can only delay the time when a *true* evaluation can be made. Likewise, the immediate and almost fanatic embracing of new ideas can produce a similar delay. Research, accumulation of all of the facts, and logic are required if we are to say, "This is the way it works," or, "This is good and that is bad."

## DIAGNOSIS

There is a growing recognition of the fact that the practice of prosthodontics makes more practical use of the basic sciences than does any other phase of dentistry. The sciences of anatomy, histology, neurology, physiology, pathology, physics,

chemistry, mechanics, and psychology are used either consciously or subconsciously whenever dentures are made. Also, the prosthodontist must know enough about all of the other phases of dentistry to know their limitations and the problems involved in them.

In order to make an adequate diagnosis, a prosthodontist must recognize normal and abnormal structures and tissues and their ability or inability to function properly. Pathologic lesions must be detected so that treatment can be instituted before dentures are made. The psychologic attitude, general health, and desires of the patient must be considered if satisfactory results are to be achieved. The quality and amount of bone and soft tissue support for the dentures must be determined by means of roentgenograms. More attention is being paid to the distribution, thickness, and health of the tissues which the dentures would cover. The dental, oral (surgical), and prosthodontic histories are essential if errors made in previous dentures are not to be repeated.

Simple observations of such mechanical factors as ridge size and shape and interridge relations are inadequate for making a diagnosis. The mechanical factors are losing their relative importance. The "flat" ridges need not strike terror in the hearts of dentists as they did formerly. The more nearly adequate impressions which are possible, a properly balanced occlusion, and the proper contouring of the denture bases can overcome the difficulties which were once considered insurmountable.

The relative importance of all of the factors which can affect the efficiency, comfort, and service of the dentures must be weighed before the correct diagnosis can be made. The appraisal of many of these factors depends, however, upon the judgment of the dentist.

Further information and research are necessary in order that each of these factors in diagnosis can be appraised in such a way that the best treatment plan can be devised for each patient. The strict adherence to a single technique for making dentures for all patients is as unsound as the prescription of a single drug or antibiotic for all diseases or for all patients would be. The diagnosis should provide all of the information necessary to guide the dentist into the use of the procedures that will meet the requirements of each individual patient. A failure to recognize this fact (this need for variations in procedures) makes dentistry vulnerable to the criticism that prosthodontics is purely mechanical. An intelligent choice of procedures for each patient according to the biologic, physical, and mechanical conditions existing in the mouth of each individual patient elevates prosthodontics to its rightful place as a health service.

## PRELIMINARY TREATMENT

There is a trend toward an increased use of preliminary treatment of edentulous patients. The necessity for achieving a state of oral health before the construction of dentures is started has been recognized. The general health of the patient is not the dentist's responsibility except as it affects his treatment. It may not be possible to establish oral health, however, until the physician has established the health of the body as a whole.

The health conditions found in the mouth are our responsibility. If pathologic lesions are present, they must be observed, diagnosed, and treated before the dentures are constructed. If the patient has been wearing dentures, the tissues which have been supporting them must be made healthy and allowed to assume their normal shape before impressions are made. If malocclusion has existed between the remaining natural teeth or between the dentures being worn by the patient, its effect upon the temporomandibular joints and neuromuscular system must be minimized. This can be done by the construction of splints, by rest (without dentures), or by conditioning exercises. Regardless of the treatment required, all tissues and structures to which the dentures must be adapted or related must be made healthy. The problem involved is the differentiation between healthy and unhealthy tissues and structures. More research in this direction will provide more positive criteria for making this differentiation.

## IMPRESSIONS

During the past year, little new has been added to the information relating to impressions. Some new techniques have been suggested, but they are simply expressions of individual preferences in the handling of impression materials and trays. Nearly all of them have as their objective the covering of the maximum area possible within the limits of the health and function of the tissues which will be contacted. All of the materials are devised to make an intimate contact with the tissues whose surfaces they are intended to record. All of them are designed to provide retention and stability for the dentures and to do this without damage to the tissues themselves.

Last year, Roberts[1] specified that impressions should not destroy the vital tissues with which they are in contact. There can be no objection to this specification, but if we are to say that one impression technique fulfills this objective better than another, we would have a hard time to support our contention in every instance. We need more positive information than is currently available about the relative effect of different impression techniques upon supporting tissues.

The opinions that have been expressed regarding tissue placement, tissue displacement, and pressure distribution and related problems have been largely empirical in nature. The clinical observations reported are inadequate for the solution of the problem. The *amount* of pressure used by one dentist may exceed the *amount* of pressure used by another using the same materials and technique. McCracken's[2] use of a weighted tray can produce uniform total pressure, but the pressure per unit of area will vary from patient to patient. We need further information about the reason why some patients tolerate more pressure than others, even where the area covered by the dentures is about the same. We need basic information about the changes which occur in tissues because of their being covered by a denture base.

## RELIEF AND BORDER SEALS

Closely related to the problems of impressions is the validity of using "relief" in dentures. Relief is provided in the upper denture to prevent a rocking of the

denture across the center of the palate and to protect the blood and nerve supply passing through the incisive foramen. The blood vessels and nerves under the denture must be protected. However, the relief of the torus palatinus should be given a more careful analysis than it has received. The shape of the relief should correspond exactly to the shape of the hard area, and its depth should be just sufficient to prevent the "rocking" of the denture. Only the dentist can make this determination. An excess depth of relief has been observed to cause pseudoepitheliomatous hyperplasia and other tissue changes. The warpage inherent in acrylic resin denture bases tends to increase the relief that has been built into dentures. Further study of these two related problems is needed badly.

The relief of certain parts of the mandibular ridge of some patients by planned pressure distribution developed in the impression still seems to be sound. However, the technique involves the use of judgment and skill, and more information about the tissue changes which result from this procedure should be obtained.

A posterior palatal seal should be used on upper dentures. This can be done satisfactorily by a tissue-displacing dam on the impression tray or by a narrow groove cut in the cast so a bead is formed on the denture. This bead should pass through the hamular notches across the palate in front of the vibrating line at approximately 2 mm. in front of the end of the denture. The narrow bead seems to be less disturbing to the tissue and more easily adjusted than a broad bead placed at the end of the denture.

## JAW RELATIONS AND JAW MOVEMENTS

The problems of maxillomandibular relationships and mandibular movement are being studied intensively by many different techniques. Mechanical tracers, lighted indicators attached to teeth, cephalometrics, motion pictures, electromyography, cineradiography, dissections, roentgenograms of the temporomandibular joints, and even "arm chair science" are being used in this activity. No doubt the information available from this research can be put together, eventually, to provide a clear picture of the way the mandible moves in function. When this is accomplished, we should know more about the jaw position or positions at which the occlusion should be established.

At present, there *seems* to be considerable disagreement about mandibular positions and about the way the mandible moves in function. Probably, if personal preferences and prejudices were eliminated, there is not as much disagreement as appears on the surface. The disturbing factor is one of viewpoint. To trust the results of a single experimental method as a basis for one's beliefs is unsound and can lead to erroneous conclusions. The solution of the problem will become simple and the true picture of mandibular position and movement will become clear when we are able to assemble all of the information obtained by all experimental methods and analyze all of the data in their true perspective. We have not yet arrived at this point in our development.

Until this time is reached, it seems wise to make the problems as simple as possible. This can be done by recognizing that the entire over-all problem can be broken down into smaller problems. Even in these *fragments* of the main problem,

there are differences of viewpoint which result in conflicting data. Jaw relations can be considered as vertical relations, horizontal relations, orientation relations, and relations assumed during function. All jaw relations should be considered as bone-to-bone relations. They should not be confused by occlusion except that the occlusion should be coordinated with certain jaw relations. By considering jaw relations and occlusion separately, we can set up specifications for each and then correlate them.

## VERTICAL RELATIONS

It is fairly well established that there are two vertical dimensions that are of significance in prosthodontics. The first is the vertical dimension at which the entire mandibular musculature is in a state of minimum tonic contraction (the mandible is in the physiologic rest position). It is a postural position of value to us *only* as a guide to the establishment of the vertical dimension of occlusion.

The second is the vertical dimension of occlusion which *must* be established for the arrangement of teeth. It must be established *before* other jaw relations can be determined, because the horizontal relation of the *parts* of the jaws with which we are concerned changes with variations in the space between them. We are not directly concerned with the condyles or the rami when we establish the vertical dimension or the horizontal (centric) relation of the mandible. No doubt the condyles play an important part in determining the positions into which the mandible may go, but we observe the relations of the residual ridges and casts made of them (rather than the condyles) as we make dentures. When we observe the lower ridge moving posteriorly as the mouth is opened, it does not mean that the *condyles* have moved back. It means only that the *part* of the mandible on which we must build the lower denture has moved back.

Some interocclusal clearance is essential to provide an opportunity for the tissues supporting the dentures and the musculature which moves the mandible to recover from the strains placed upon them. While certain amounts of interocclusal distance have been recommended, it seems more logical to expect to find considerable variation in the requirements of different patients.

The registration of the physiologic rest position is not as simple and foolproof as it once appeared to be. Atwood[3] showed it to vary from time to time, and the relative physical and mental tenseness or tranquility of the patient may affect its registrations. It is possible, also, that the space available for the tongue may be a factor contributing to the establishment of the vertical dimension of rest position. We should find out if varying thicknesses of the palate would cause the physiologic rest position to vary.

## HORIZONTAL RELATIONS

The important horizontal relations of the mandible to the maxillae are those existing when the teeth or other occluding surfaces are in contact. They are the centric relation and all eccentric relations.

Centric relation has been defined in so many ways by different people that it has connotations that differ according to the individual. Most of the existing

definitions are confusing unless one knows the concept of the person using the term. It is time that we recognize the *reason* for having such a term. The term centric relation is necessary to designate a specific relationship of one jaw to the other. The relationship must be a repeatable one in the horizontal plane at the *established* vertical dimension. It can be *only one* relation, or it will not be repeatable. It must be specific enough that different dentists can locate and record it with identical accuracy. It must be usable as the reference relation for the establishment of *any* desired occlusion.

The definition I am suggesting is: Centric relation is the most posterior relation of the mandible to the maxillae at the established vertical dimension. There are no qualifying clauses except that of prior establishment of the vertical dimension of occlusion. It is a specific reference relation to which other jaw relations may be referred. Any occlusal scheme may be related to it by being built at the centric relation or at some specific eccentric relation as desired. For example, it may be desirable to build the occlusion at a habitual or acquired eccentric position 1.0 mm. anterior to centric relation. This definition makes it possible for this to be done by following specific directions. Or, a "functional area"[4] of occlusion could be established 1.5 mm. in front of and to the left of centric relation, if desired. Naturally, it would seem desirable to establish the occlusion so that the teeth would meet evenly at centric relation as well as in the "habitual or functional" occlusal position.

Considerable disagreement has been expressed about the way centric relation is used in the technical phases of prosthodontics. Some argue that all dentures should be built so that centric occlusion coincides with centric relation. Others insist that the occlusion should be established to coincide with the position into which the patient closes by habit. I see no reason why both conditions cannot be established in the same occlusion, provided the *one* centric relation has been recorded as a reference relation.

Some anatomists and some dentists have expressed doubt about the desirability of establishing the occlusion at centric relation. This seems to me to be a dangerous concept, even if it is true. Unthinking dentists may tend to use this concept as an *excuse* for failing to record centric relation accurately. It is probably more difficult to record a habitual or functional relation accurately than it is to record centric relation accurately. Much more information is needed before we can disregard centric relation as *the* basic horizontal jaw relation.

## ECCENTRIC RELATIONS

There is considerable difference of opinion regarding the value of eccentric occlusion, and, therefore, there is considerable difference of opinion regarding the value of making eccentric relation records. The conflict revolves about the way in which people chew. Some believe that mastication is accomplished by a simple hinge movement; others believe that the "chewing cycle" is teardrop in shape, with the closure ending at centric occlusion; others believe that the closure is directed to a cusp-to-cusp contact of the teeth followed by a glide to centric occlusion. Strange as it may seem, I believe that *all* of these concepts are correct *part of the time* for

most patients. No one chews every morsel of every type of food exactly the same way. If a bite of food happens to slip off of the teeth, the chewing cycle will be altered to get it back on top of the teeth where pressure can be applied against it. Chewing involves a neurophysiologic process maneuvering the teeth into positions where they can do the most good. The effectiveness of this process is emphasized by the fact that no comparable or successful mechanical chewing device has been constructed. I admit that food grinders can do a better job of comminuting food than teeth, but they do not have rows of teeth that press against food, separate, and press again as teeth must do.

If we can admit that teeth do occlude in eccentric jaw positions, even rarely, we must admit the importance of eccentric jaw relations. If the occlusion is to be balanced the same in the mouth as it is on the articulator, the eccentric jaw relations must be recorded and the articulator adjusted accordingly. Whether or not a single eccentric jaw relation record is adequate is one of the unsolved problems.

## ORIENTATION

The third type of jaw relationship of importance in denture construction is that of orientation. It involves the relation of both jaws to the joints between the jaws. It is important in the establishment of the occlusion if the vertical separation of the casts is changed on the articulator and in the *approach* to occlusion from an open jaw position. It is recorded by means of a face-bow.

Unfortunately, the face-bow is the first piece of equipment many graduating dentists discard in their efforts to streamline their denture procedures. It is unfortunate because the face-bow can really *save* time for the dentist by holding the casts in position while the mounting plaster sets.

There are severely contrasting attitudes about the value of the face-bow. At one extreme, there are those who say it is of little or no value. And they may be right if they compensate for not using it by adding other procedures to their technique. Stansbery[5] did this by using four interocclusal records, one at centric relation and three others at eccentric positions *with the vertical dimension increased by the amount of the cusp height.*

At the opposite extreme, there are those who say the arbitrary face-bow is not accurate enough. They insist that it is necessary to locate the exact point on the face which is on the axis of the posterior hinge movement of the mandible. There is doubt that the hinge axis can be located *exactly* when the recording bases which support the hinge-bow are supported by displaceable tissues.

There is also some question about the existence of a true hinge movement in the temporomandibular joint because of the shape of the condyle and the fossa in which it is supposed to rotate. The irregularity of the contacting surfaces in these joints and in the posteromedial angulation of the long axes of the condyles tends to support this doubt.

The problem of orientation has been complicated by some technical approaches to it. Some have placed great emphasis upon the fact that the condyles are not at the same level in most heads. On the basis of this, they have varied the height of the condyle mechanism on the two sides of their articulators. By doing this, they

are able to mount the casts so they are level with the bench top. This seems to be of no importance since the dentures must function in the mouth without being level with the floor. Equal results can be obtained by having the casts mounted "off center" in the articulator so they have the same orientation to the bench top and the axis as they have in the mouth. Frequently, this has an advantage when the problem of esthetics is approached.

The problem of orientation is further complicated by those who insist that each condyle operates independently. This is obviously impossible because both condyles are parts of the same bone. Since the mandible is a solid mass, any motion of it must involve all parts of it in a coordinated manner. The fact that the long axes of the condyles are not on the same line and one condyle may be higher or farther back than the other does not alter the hinge movement except in the direction of the plane of movement.

The problem of orientation is further complicated by attempts to consider the posterior terminal hinge position of the mandible as being *different* from centric relation. The posterior terminal hinge position can be considered as a means for locating centric relation *provided* the vertical dimension of occlusion has been established first.

A second type of orientation is possible by relating the mounted casts to certain cranial landmarks. In most instances, these cranial landmarks are selected arbitrarily. They seem to be of value only to produce consistency in the establishment of the position of the occlusal plane between the upper and lower members of the articulator. This, of course, permits a comparison of the condylar paths of one patient to those of another. Otherwise, the results and controls are the same because all motion is relative. If the occlusal plane is inclined downward in front 15 degrees more in one articulator than in a second articulator, the condylar guidances will indicate an inclination 15 degrees steeper in the first articulator than in the second. The net result is the same because it is the angle between the occlusal plane and the condylar guidance which is important to occlusion.

There is one advantage in having the occlusal plane mounted at the same relation to the bench top as it has to the floor when the dentures are in the mouth and the head is held upright. This advantage is in working out esthetic problems and has nothing to do with mechanics. It makes it possible to observe the anterior teeth on the articulator at the same angle (in profile) as they will have in the mouth. If the *front end* of the occlusal plane is mounted at a higher level on the articulator than it occupies in the mouth, the incisal edges of the anterior teeth will incline farther lingually in the mouth than they do on the articulator.

## JAW RELATION RECORDS

You will note that I have separated the discussion of jaw relation *records* from the discussion of jaw relations themselves. The reason is that much of the confusion and misunderstanding regarding jaw relations has resulted from attempts to use the methods of making the records as the basis for discussing the relations.

## PHYSIOLOGIC REST RELATION RECORDS

Physiologic rest relation records are used for establishing the vertical dimension of rest position. Many techniques have been suggested and used for making these records, but *all* of them are based on activities carried out by the patient. Therefore, these records are subject to possible variations and errors resulting from the physical condition, the mental attitude, and the habits of the patient. Conditioning exercises, hot packs, and mild sedation have been used to overcome the difficulty of getting the patient to relax so an accurate record can be made.[6] The tensions, anxiety, or overzealousness of the patient may cause an error in the record. These factors are involved whether the method used involves simple measurements, electromyography, cephalometrics, sagittal tracers, or observations of the teeth at rest and during speech. Judgment is required in evaluating *any* of these records so the recording of physiologic rest position involves a *double* subjective record. It is subjective on the part of the patient as he *tries* to do what the dentist wants, and it is subjective on the part of the dentist as he *tries* to evaluate what the patient has done. This leads me to question the wisdom of placing *absolute* dependence upon physiologic rest position as the means for determining the vertical dimension of occlusion.

## VERTICAL DIMENSION OF OCCLUSION

Many methods are used for establishing the vertical dimension of occlusion. All of them are subject to error because all of them require the dentist to use his judgment in one way or another. Most methods make some use of the vertical dimension of rest position (which has been shown to be subject to possible error) as a starting point. Then the occlusion rims are reduced in height to allow for interocclusal clearance. The dentist must exercise his judgment as to the amount of interocclusal clearance required for each individual patient. This is difficult to do because of the same pathologic, physiologic, and mental factors involved in locating the physiologic rest position. Arbitrary amounts of interocclusal clearance will not be correct for all patients.

The establishment of the vertical dimension of occlusion by recording the amount of closure during swallowing, as suggested by Shanahan,[7] involves a direct approach to the problem. The repeated swallowing activity with closure against soft wax and stopping at the level of normal occlusal contacts seems to be sound. However, a number of conditions *might* modify the amount of closure achieved by the patient. Among these are tenderness of the ridges, tensions, habit, overzealousness to "test" their wax dentures, the thickness of the palate of the recording base, etc. This approach to the establishment of the vertical dimension of occlusion should be studied further because it offers an opportunity to balance the results obtained by other methods.

The appearance of the patient has been used as a guide for the vertical dimension of occlusion. However, failure to establish the correct anteroposterior support of the lips before this observation is made has had tragic results. It has caused the vertical dimension of occlusion to be too great.

None of the present methods *alone* can be said to be absolutely reliable for all patients.

An appraisal of phonetics, esthetics, and the parallelism of the ridges correlated with each other and with the physiologic rest position should be considered in the final analysis of the vertical dimension of occlusion. In other words, the measurement indicated by any one method should be checked against those of other methods.

### CENTRIC RELATION RECORDS

Most centric relation records are made by means of interocclusal records either with or without the use of tracing devices. When the tracing devices are used to visualize the horizontal relationship between the two jaws, there seems to be too much reliance placed on the accuracy of the records. Unfortunately, these records are subject to errors which result from the displacement of the tissues which support the recording mechanism (the tracers). Variation in the amount of closing pressure applied at the time the record is made can produce incorrect records even though the needle point remains in the apex of the tracing.

Centric relation records made without the guidance of tracings may be incorrect, also, for the same reason. This type of interocclusal record will be incorrect if there is any interference between the occluding surfaces of the recording bases at the time the record is made.

Various methods of equalizing the pressure distribution over the denture-supporting areas have been suggested. However, these devices *may* be subject to the same kind of errors in stress distribution as the central bearing point. More information, observation, and research about these instruments and procedures are needed.

It is apparent that all centric relation recording techniques are subject to possible error. In addition to the purely technical errors which can occur are the errors inherent in failure to control the patient's jaw activities and pressures at the time the registration is made.

All of these errors (by whatever method) are more likely to occur if the denture foundation is poor than if it is favorable. A recording base that changes its relation to the underlying bone (either vertically or horizontally) while the record is being made will produce an incorrect record *regardless of the method used.*

There seems to be no doubt that correct centric relation records can be made by every method yet devised. Every centric relation record (regardless of method), however, should be subjected to critical observation and rechecking, because no method is foolproof. The dentist's attitude should be one of attempting to prove that each record is wrong, and if he cannot prove this, the record is likely to be correct.

### ECCENTRIC RECORDS

The methods for making eccentric relation records are similar to those used for making centric relation records. They are subject to the same types of errors as are possible in centric relation records.

ARTICULATORS

There seems to be a resurgence of interest in articulators which could lead to a repetition of the stormy debate about articulators that characterized the period from 1918 to 1933. The stimulus for this interest has been provided by the proponents of Gnathology, Transographics, and others. The arguments are being presented with different terminology, but the problems being discussed are amazingly similar to those discussed in the period when any prosthodontist worthy of note had designed his own articulator. The active participants in the current controversy are as positive in their statements as were the rugged individualists of the "articulator war." It will be interesting to follow this new struggle, but no articulator can do more than reproduce the specific jaw relations that are transferred to it from the mouth. All other jaw relations on any articulator are educated approximations. If a static centric relation record and one static eccentric relation record are adjusted into an articulator, the articulator can be precisely accurate *only* at those two positions. Of course, the real weakness in any articulator used for making complete dentures is the record or records which are used to adjust the instrument.

OCCLUSION

The differences of opinion regarding occlusion and the design of the occlusal surfaces of posterior teeth remain as great as ever. Those who favor posterior teeth without cusps seem to be just as sure they are right as those who favor cusp teeth are sure they are right. It is likely that both schools of thought regarding occlusion and tooth forms are at least *partly* right. If either of these concepts was *entirely* wrong, the patients with dentures made with the incorrect type of occlusion would not be able to wear them at all or every ridge under all of the dentures built with the incorrect type of occlusion would be destroyed rapidly. Obviously, neither of these results occurs with consistency when either type of occlusion is used *correctly.*

Two factors influence the results regardless of the type of occlusion. First, the accuracy with which the occlusion is developed to harmonize with the jaw relations (primarily centric relation) is important to the "success" of the dentures. If this is not done correctly, the dentures or the supporting structures will fail, regardless of the kind of teeth used. Second, the attitude, adaptability, and tolerance of patients may determine the clinical success or failure of either *type* of occlusion.

There is a great need for a means for evaluating the effects of different types of occlusion on the supporting structures and on the temporomandibular joints. *Clinical appraisal seems to be too unreliable.* Until basic research can be accomplished, the advocates of any specific type of occlusion might well use a little restraint in their claims.

ESTHETICS

There has been a remarkable revival of interest in the esthetics of dentures in the last few years. This change is more noticeable because so little attention had been paid to esthetic requirements for some time. The textbooks had assigned

certain relative lengths and inclinations to the teeth and certain relationships to the residual ridges which gave dentures a more or less uniform appearance. The relegation of much of the tooth arrangement to dental laboratories contributed to the mechanical appearance of dentures. The laboratories followed the textbook specifications without question, and many dentists failed to change the basic arrangement to one in better harmony with the individual patient's needs.

The relationship most damaging to good appearance was the use of the "ideal" vertical and horizontal overlap without consideration for the horizontal relations of the ridges. Perhaps dental schools should no longer teach the "ideal" tooth arrangement. Instead, they might place greater emphasis upon the relations of natural teeth to the alveolar ridges from which the teeth erupt. The only correct position of a tooth is the one in which it was placed by Nature. Efforts to improve the patient's appearance by making the *dentures* look nice often result in disappointing and unflattering facial expressions. The appearance of the face is more important than the appearance of the dentures.

Any fixed plan for anterior tooth arrangement will result in dentures with a characteristic similarity. This can be avoided by modifying the plan to copy natural tooth arrangements as closely as possible. A great danger exists in the tendency to make all dentures look alike. If the tooth arrangement on one set of dentures looks particularly good, we will tend to set up the teeth for the next patient the same way. This should be avoided.

The greatest need, so far as esthetics is concerned, is to find a way to cause *dentists* to take the interest they should in arranging the anterior teeth. Too much of this work has been shifted to the laboratory technician *without adequate subsequent reappraisal and rearrangement* of the anterior teeth by the dentist. The laboratory technician cannot know the effects of standardized tooth arrangements on the appearance of patients. If the dentists do not take the time and the interest in this phase of denture construction to do it right, they are inviting the "denturists" to take over prosthodontics in the same way that optometry was taken from ophthalmology.

## LABORATORY PROCEDURES

Despite all claims to the contrary, the resins available for dental use are not as good as the manufacturers would like us to believe. To make a simple clinical test of this statement, all that is needed is to compare the fit of a gold denture base and an acrylic resin base made from the same cast.

## INSTALLATION PROCEDURES

It is becoming increasingly apparent that the occlusion of all new dentures should be corrected by being remounted with new interocclusal records on the day they are inserted in the patient's mouth. This procedure permits occlusal corrections to be made *after* the warpage occurring when the casts are removed from the dentures has occurred and *before* the malocclusion resulting from *any* cause has had an opportunity to distort the supporting tissues.

## POSTOPERATIVE CARE

Since dentures are therapeutic agents which may act favorably or unfavorably upon the tissues which support and surround them, periodic inspections are necessary. There is an apparent increase in the incidence of pseudoepitheliomatous hyperplasia under upper dentures. The cause of this is not known, but excessive relief (which may result from warpage of the denture base) and errors in occlusion are suspected. If this condition is detected and corrected in time, the results are not serious. If not, they may be disastrous.

## UNANSWERED QUESTIONS

There are many unanswered problems relating to prosthodontics. I have given my *opinions* on the answers to some of them, but I reserve the right to be wrong the same as anyone else who may attempt to evaluate the current status of prosthodontics. The following is a list of the problems that occurred to me as I was attempting this analysis:

1. How can the quality of bone for the support of dentures be determined accurately?
2. What factors determine the choice of procedures to be used for each individual patient?
3. What is the nature of healthy and unhealthy denture-supporting tissues and structures?
4. What are the specific cellular changes that occur when pressures are applied to denture-supporting tissues?
5. What is the specific effect of varying amounts and types of pressure on tissues under dentures?
6. Why do some patients tolerate more pressure from dentures than others?
7. What are the changes in tissues which are covered by dentures?
8. What are the changes in tissues which are relieved to the extent of being in a vacuum?
9. How can we best coordinate and correlate and analyze the available data regarding jaw relations, jaw movement, and jaw function?
10. What part does the tongue and palate thickness of dentures play in the establishment of the physiologic rest position?
11. What is the true significance of centric relation?
12. Are "habitual" or "functional" eccentric relations adequate for the establishment of occlusion?
13. Can a tooth-testing chewing machine be made to masticate food the same way as the mouth does?
14. Are eccentric jaw relations important in denture construction and denture function?
15. Is a single eccentric jaw relation record adequate?
16. Can the hinge axis of the mandible be located with accuracy when the recording bases are attached to displaceable tissues?
17. Is it necessary to be completely accurate in the location of the hinge axis?
18. Is there a true hinge movement in the temporomandibular joint?

19. Of what value is orientation of occlusion to cranial landmarks?

20. Which is the ideal cranial landmark for orientation and why?

21. Can the physiologic rest position be established with repeatable accuracy? How?

22. Is the "free" swallowing activity sufficiently constant to establish the vertical dimension of occlusion?

23. How effective are the various stress-distributing devices used in connection with interocclusal records?

REFERENCES

1. Roberts, A. L.: Present-Day Concepts in Complete Denture Service, J. Pros. Den. **9**:900-913, 1959.
2. McCracken, W. L.: Stabilizing the Lower Impression While Recording the Periphery in Functional Positions, J. Pros. Den. **8**:600-608, 1958.
3. Atwood, D. A.: A Cephalometric Study of the Clinical Rest Position of the Mandible, J. Pros. Den. **8**:698-708, 1958.
4. Boos, R. H.: Centric Relation and Functional Areas, J. Pros. Den. **9**:191-196, 1959.
5. Stansbery, C. J.: The Futility of the Face-Bow, J.A.D.A. **15**:1467-1472, 1928.
6. Boos, R. H.: Preparation and Conditioning of Patients for Prosthetic Treatment, J. Pros. Den. **9**:4-10, 1959.
7. Shanahan, T. E. J.: Physiologic Vertical Dimension and Centric Relation, J. Pros. Den. **6**:741-747, 1956.

The Ohio State University
College of Dentistry
305 West Twelfth Ave.
Columbus 10, Ohio

# THE EXTRAORAL TRACING AS AN AID IN TOOTH SELECTION

W. D. Pearson, D.D.S.
*Chattanooga, Tenn.*

The search for the ideal tooth form for the edentulous patient will continue into the future. Since Hall made the radical shift from high cusps to inverted cusps, the problem has received much consideration. The majority of conclusions support either cuspid, flat, or modified forms of teeth.

The fact that authorities differ in their opinions indicates that satisfactory dentures are made with various tooth forms. Not all patients are alike. They present considerable differences in the many factors that go into the development of the components of occlusion. There are considerable differences in the anatomic, histologic, and physiologic conditions of the components of occlusion in patients at the time dentures are required. It is logical, desirable, and practical to select the tooth form that will produce the best results for each individual patient rather than to select the tooth form that will be suitable for the greatest number of patients. Research in this field is badly needed.

This article will discuss only one of the aids the prosthodontist may use to determine the tooth form best suited for each individual occlusal pattern.

## EXTRAORAL TRACING

A careful analysis of the extraoral needle-point tracings furnishes information that is useful in selecting the tooth size and form best suited for the individual patient. A minimum of two tracings must be studied—one made by the patient without direction and one made by the patient following specific directions. The extraoral tracing appears in many different patterns. I will discuss three general groups of patients.

*Group One.*—These patients produce the perfect geometric pattern with an even, narrow line. The scribing pointer consistently comes to rest at the apex of the tracing upon opening and closing. The movements are accurately executed when instructions are given. The evidence of good muscular coordination and mandibular control indicates that the patient will be able to function efficiently and comfortably with an occlusal pattern utilizing high-cusp forms. The length of the lateral lines indicates the width of the occlusal pattern for any tooth form selected.

*Group Two.*—These patients make an accurate geometric pattern with wide lines. The scribing pointer consistently comes to rest within the range of the boundary line upon opening and closing. When directed, the movements are executed with the scribing pointer remaining within the boundary of the lines. This group of patients has good mandibular control. The width of the scribed line is

the guide to the amount of anteroposterior cusp clearance that the patient will require for comfort, efficiency, and ridge preservation.[1] When this procedure is applied, shallow cusps are formed on the teeth to produce efficient, comfortable dentures.

*Group Three.*—These patients cover all or a great part of the surface within the boundary of the tracing. The scribing pointer may come to rest in any position upon opening and closing, rarely in the same place. The patient follows directions with difficulty, or not at all, and has poor muscular coordination and mandibular control. These patients will be more comfortable and their ridges will be better preserved if the dentures are constructed with flat teeth.

This procedure of tooth selection is not suggested as an infallible rule. However, it has proved to be a valuable guide in selecting the occlusal pattern best suited to the individual patient.

REFERENCE

1. Pearson, W. D.: Reducing Frictional Resistance in the Occlusion of Dentures, J. Pros. Den. **5**:338-341, 1955.

938 McCallie Ave.
Chattanooga 3, Tenn.

# THE MANDIBULAR HINGE AXIS AND A METHOD OF LOCATING IT

B. B. McCollum, D.D.S.
*Sepulveda, Calif.*

THE HINGE AXIS IS AN IMPORTANT ROTATION CENTER of mandibular movements. It was recognized early by anatomists and physiologists, but its full significance to dentistry has not yet been realized.

## PREVIOUS RECOGNITIONS

The written story of the mandibular hinge axis goes back into the first editions of Gray's *Anatomy*. Gray and those following him recognized that the mandible moves on a hinge as well as by means of the forward and lateral movements of the condyles in the glenoid fossae. The temporomandibular articulation was called a "ginglymo-arthroidal joint" by Gray. But up until the time of Bonwill, American dentists treated the joints as if they have only hinge action; this is evidenced by the hingelike articulators they invented and patented.

Balkwell of England, in 1824, called attention to the sliding actions of the joint. However, dentists nowhere in the world gave attention to his article, perhaps because it was too well stored away on a shelf of a London library.

Bonwill assumed that the forward motion of the joint was on a straight line in a forward direction. This idea held precedence for 40 years, until Walker proved that the motion was forward and downward.

Bennett of England, unaware of what Balkwell had written in 1824, showed that the condyles in all individuals make a side-shift motion to a greater or lesser extent in the lateral movements. This is well known as the Bennett movement.

Snow recognized the hinge axis as important to the other jaw motions, and he contrived the face-bow for transferring this axis to a mounting instrument.

## UNHARNESSED KNOWLEDGE

I regret that none of these men followed their discoveries to a precise, constructive, logical conclusion. Bennett and Balkwell never did much to make their discoveries useful to dentistry. Snow was satisfied to grossly approximate the location of the condyle by palpations, and others following him tried to locate the axis by arbitrary formulas of a set measurement, using the tragus of the ear as the starting point. They did not give their findings any clinical value in the practice of dentistry. They never learned how to harness their knowledge to use it in effecting remedies for the mouth.

---

Read before the Chicago Dental Society, Chicago, Ill.

The fine precision of the temporomandibular articulation remains even today unappreciated by the teaching staffs of our dental schools. They generally use a simple instrument that by no means reproduces the true movements of the mandible.

### CONTROVERSY AND CONFUSION

No other topic starts more disagreement and heated controversy in oral physiology than the role of the jaw joints in dental articulation. Even how and what muscles activate the movements of the mandible are still in controversy. The ideas about what part the temporomandibular joints play in jaw motions run the gamut of the following: (1) the belief that they play no part at all (the movements being interpreted as purely neuromuscular in action), (2) the claim that the joints are adaptable to the arrangement of the teeth, and (3) the idea that the jaw joints have complete control of all the directions of all mandibular movements. This confusion means that not enough serious thinking has been done with demonstrable facts. Herbert Spencer said that truth can come out of error but never out of confusion. But why should confusion about the mandibular motions last so long? American dentistry boasts of being more than a hundred years old. We have been confused about the actions of the jaw joints all this time. That is a whole century of confusion.

### INFLUENCE OF WADSWORTH AND SNOW

In 1922, while doing some postgraduate work with Dr. Frank Wadsworth (who, I believe, was the first dentist to call attention to the necessity for definitely orienting the casts on an articulator), I became aware that there was something lacking in what we were doing in complete denture work. I had read Snow's articles on articulation and the use of his face-bow. He showed, graphically and geometrically, the influence of the mislocation of what he called the opening axis of the jaw. Snow taught that one type of mislocation would cause the anterior teeth to strike first when the dentures were transferred from the articulator to the mouth. Another type of mislocation would cause the molars to strike first when the dentures were taken from the articulator to the mouth. The results we obtained in our attempt to fabricate dentures for a patient showed definitely the result of a mislocation or a failure to locate the opening axis.

This bad result was not easy to see because of the movement of the denture bases on the supporting tissues. Snow's graphic illustrations were demonstrated to me clinically. The molars contacted but the anterior teeth did not. That indicated to me that the "hinge" was wrong. It seemed reasonable that if there were a hinge axis, and the evidence before me indicated that there was one, it should be located and reproduced on an articulating instrument.

### PERSONAL INVESTIGATIONS

My first attempt to locate the hinge axis was made with the ordinary Snow face-bow, rigidly attached to the mandibular teeth by means of a stud fastened to the mandibular teeth with modeling compound. I used small pencils with the lead pointed in the recesses of the calipers in order to see well.

By having the patient open and close the jaws in a rhythmic manner without a protrusive movement, it was evident almost at once, as I watched the caliper of the face-bow, that the jaw did have a true hinge action.

Pursuing through several years the work begun by Balkwell and furthered by Walker, Gysi, Bennett, and others, the Gnathological Society of California, under my direction, determined to investigate what these men had started, but to use more precise methods. It was necessary to devise methods and instruments of investigation that did not in themselves create errors.

A means of attaching our instruments so that they, figuratively, became a part of the mandible was developed. Grossly, our instruments were not unlike those of Walker and Gysi. The basic ideas of our investigations were almost identical with those of Balkwell, Walker, Gysi, and Bennett. However, the difference was in the precision of our instruments and the vital point of the *rigid attachment* of our instruments to the mandible.

It is not so difficult to obtain rigidity of attachment to the maxillae, because they are stationary. At first we made a great effort to fix our instruments to the mandible and maxillae so as not to interfere with cuspal relations. This idea of non-interference with the cusps made it hard to formulate and apply attachments with the required rigidity. However, it could be and was done. Later, we found that the pure opening axis of the mandible, without any forward movement of the condyles (that is, without bringing the external pterygoid muscles into action), was much greater than we had supposed. This discovery simplified our procedures. We could use a simple device, which we called a "clutch," that was reasonably easy to make and ensured absolute rigidity of our recording device. And finally, after getting away from all cuspal interference, we incorporated into the clutches the contribution of Phillips, a "center-bearing" point. This did much to augment our investigations of joint activity during mandibular motions.

## DEVELOPMENT OF AN ARTICULATOR

We proved the preciseness of our analyses by duplicating our records of jaw motions time after time. After we had succeeded in creating an articulating instrument that would duplicate the jaw motions, we demonstrated that after the Gnathoscope was set to duplicate the records of the patient we could make records on the set instrument that would in turn be duplicated by the patient. In other words, the experiments were done forward and backward. Such an experiment involved the creation of conditions that are not applicable to ordinary clinical work, but these tests were made to establish the validity of our results.

## TRIAL AND ERROR METHOD

Our experiments showed conclusively that there are no external anatomic landmarks that would indicate the position of the opening axis and that this position could not be found by palpating the joint or by measuring a distance in any direction from the tip of the tragus. The hinge axis must be determined instrumentally or experimentally.

After a lot of almost heartbreaking work, we had to fall back on the plain trial and error method. We even went so far as to begin the construction of a geometric instrument that would indicate the location of this axis in the patient. However, we soon found that the instrument had to be so delicate and so precise that manufacturing it was practically a physical impossibility.

Our problem in making this geometric instrument was similar to that of finding the center of a circle 4 inches in diameter from an arc ½ inch long. Theoretically that could be done, but it would require ultra-precise instruments.

### ANATOMIC FEATURES

The general anatomic forms and the structure of the temporomandibular joints and the muscles of mastication are well described and accepted as basic knowledge. However, what these joints do and how they do it are the controversial points usually discussed.

### PECULIARITIES OF THE MANDIBLE

In no other part of the body do we find two joints formed to act in unison with one on one side of the body and the other on the other side of the body. When one joint moves, the opposite joint must make a compensating change of position. This, of course, is brought about by the union of the two halves of the jaw at the symphysis menti.

### CENTRIC RELATION

The movements of the mandible are in three dimensions: (1) up and down, (2) forward and back, and (3) right and left. All of these movements have a common starting point which has become known as centric relation. There is even some controversy about this starting point. I define it as "the most retruded positions of the *idle* condyles in the glenoid fossae." Even the anatomic form of the joint indicates that this concept is correct.

### THE JOINT

The temporomandibular joint consists of a fossa, a meniscus, and a condyle all wrapped up in a capsular ligament. The fossa has a curved floor (or roof) ending in the anterior portion as an eminentia. The fossa also has a posterior wall and a medial or inside wall. The meniscus covers the condyle and through it the contact of the condyle with the surface of the fossa is made. The meniscus really caps the condyle. The attachment is such that the bony condyle with its fibrocartilaginous covering can rotate on the underside of the meniscus through the medium of a synovial membrane which secretes the necessary fluid to make this movement possible. The meniscus or disk is so attached that it moves with the condyle in any forward or lateral movement of the jaw.

### OPENING-CLOSING AXIS

In any up-and-down movement of the jaw, the condyles rotate on or in the disks in much the same manner as a condyle of a finger joint rotates in its fossa

during extensions and inflexions. The center of rotation in both the finger joint and the jaw joints is somewhere in the body of the condyle, much the same as the center of rotation of a common hinge is in the center of the hinge pin no matter how large the pin. The center of action is not on the surface of the disks but down in the condyles. This axis is the hinge axis of the mandible.

### HINGE AXIS AND OTHER MANDIBULAR MOVEMENTS

As the disks move with the condyles on the floor (or roof) of the temporal (mandibular) fossae, the hinge axis remains constant in its relations to the mandibular teeth, or in an edentulous jaw to any other given part of the mandible in any position that the jaw may assume. The center of action of the hinge axis component is in the same position in the condyle, whether the mandible is in centric position or in a lateral or protrusive position. If the hinge axis of the joints is combined with the sliding action of the meniscus, there is an apparent center of action for these combined components of jaw action in the region of the lobes of the ears. Apparently, Gysi was at first deceived by this action. This apparent center of action is not a hinge, and its position depends on the amount of forward movement of the meniscus and the amount of hinge axis opening, together with the amount of downward movement and the degree of curvature of the condyle path. This apparent center of action is not constant; its position varies as the combination of the amount of the hinge axis component and the forward and downward component varies in its order of arrangement. For instance, if the mandible opened ¼ inch on the hinge axis in the second molar region and the condyle moved forward ¼ inch in the fossa, this apparent center of the combined movement would be in one position. If this combination of the components of action were changed to ½ of an inch on the hinge axis and ½ inch in the forward movement of the condyle, the apparent center would change its position accordingly, and so on through a myriad of possible combinations.

### COMBINATIONS OF COMPONENTS AND CONFUSION

No doubt this apparent center of action has caused most or all of the confusion surrounding the hinge axis and the other complex combination motions of the mandible. When the three basic motions of the jaw (opening and closing, forward and backward, and right and left) are studied simply, then combined, the "complicated" results of their combinations are easily understood. All the seemingly complicated motions of the mandible in mastication are simply the result of combinations in varying proportions of these three simple movements.

### NECESSITY OF REPRODUCTION OF MANDIBULAR MOVEMENTS

With these three simple basic movements reproduced accurately in an articulating instrument, it becomes possible and even simple to reproduce all the various combinations of the masticatory movements of the mandible. While it is not the purpose of this article to discuss jaw motions in their entirety or their reproduction

in an instrument, it is necessary to touch upon the other motions to show the importance of the hinge axis.

The hinge axis is a component of every masticatory movement of the mandible and, therefore, cannot be disregarded. The hinge axis of the articulating instrument must be a duplicate of the hinge axis of the jaw, or there can be no mechanical reproduction of jaw motions.*

### INCOMPRESSIBILITY OF THE MENISCUS

The meniscus is made up of a fibrocartilaginous tissue which by its very structure does not lend itself to compression or distortion. Scientific clinical experiments demonstrate that the "compressibility" of the meniscus does not exist. The fact that the temporomandibular joint can be subluxed has added considerable confusion to understanding the action of the joint. However, this subluxation is also true of the joints of the fingers and all of the movable joints of the body. It is apparent what would happen to the fingers or other joints if they were expected to function in a subluxated position. So it is apparent what happens to the jaw joints when any arrangement of the teeth causes even a slight subluxation of the joints. The injury of the jaw joints would be similar to what happens to other joints when they function out of their proper positions, as, for instance, the production of certain occupational diseases caused by bad posture, etc.

### RESTING PLACE OF THE CONDYLE

The posterior portion of the glenoid fossa, the postglenoid process, together with the floor of the fossa, forms a perfect resting place for the idle condyle. Roentgenographic evidence as to the position of the condyle in the fossa can be, and generally is, very misleading. The bony structures of the joint do not indicate the actual joint; a great deal of the joint in many patients is composed of cartilage which is transparent to the x-ray. This condition is easily demonstrated in the roentgenogram of the hand of a child. If we took roentgenographic evidence alone, we would be forced to say that there were not any joints in the hand. If we did not know that the cartilages were present to make the joints complete, we would be forced to say that the hand of a child could not function. Therefore, we must turn to methods other than roentgenography to determine what these joints actually do and the position of centric relation.

### MASTICATORY MUSCLES ARE MOTORS

The joints are activated by a set of "muscles of mastication." These muscles are the power plant for all the movements of the joints. The muscles can be compared to the engine in a car, while the joints can be compared to the steering gear because they direct the course of the movements. The muscles furnish

*A series of articles on jaw motions and their reproduction was published in 1939-1940 in *Dental Items of Interest* under the titles, "Fundamentals Involved in Prescribing Dental Remedies" and "The Articulation of Human Teeth," and was reprinted as "A Research Report" of the Gnathological Society, Inc., of California and as the article, "Oral Diagnosis," in the J.A.D.A., August, 1943.

the power by which we open and close the mouth, protrude and retrude the mandible, and make what are known as the right and left lateral movements. Some of these muscles act in a dual capacity, i.e., some of their fibers both close and retrude the mandible. For instance, the posterior medial fibers of the masseter muscles indicate by their direction that they have to do with retruding the mandible. The posterior fibers of the temporal muscles, which are the mightiest muscles of mastication, definitely indicate by their direction that they can exert great force in retruding the mandible. The anterior lateral fibers of the masseter muscles are so arranged that, when the mandible is protruded, they can exert the maximum of their force in closing.

The internal pterygoid muscles act as a pair. In addition to their closing action, their purpose is to guide the mandible in the lateral movement so that the condyle follows the inner wall of the fossa. The position and shape of this inner wall determine the absence of or the amount of the side shift, or Bennett movement, and the character of this movement—whether it is a straight or curved line. When the mandible moves in right lateral movement, the left condyle travels in the glenoid fossa. The left internal pterygoid muscle guides the condyle on the inner wall of the fossa as the external pterygoid muscle pulls the condyle forward in the fossa. The action is reversed in the left lateral jaw motion.

### THE EXTERNAL PTERYGOID MUSCLES

The external pterygoid muscle is attached both to the condyle and the meniscus. The gliding movement of the joints takes place between the upper side of the meniscus and the surface of the fossa. This contact is made through the medium of a synovial membrane which secretes the fluid and makes the movement possible. The posterior wall of the glenoid fossa is described as an articulative surface known as the postglenoid process.

The external pterygoid muscles are specialized in that they indicate by the direction of their fibers that they only protrude the mandible. When acting together, they produce simple protrusion, or acting singly, they produce the right and left lateral motions.

The external pterygoid muscles have been credited as taking part in the simple opening of the mouth. This deceptive concept is the result of the fact that when the human being opens his mouth by reflex, he does it instinctively for the purpose of incising something. In the widest opening of the mouth, the condyles are brought forward to their extreme position.

### WHY CONDYLES ARE PROTRUDED

The only logical explanation for the condyles being brought forward in the wide opening of the mouth was given to me verbally by Dr. John R. Thompson. He called attention to the fact that if the pure hinge axis was used in opening the mouth widely, the posterior part of the ramus (just below the condyle) would impinge on the complex tissue behind and below the glenoid process. Through this space below the glenoid process pass the chorda tympani branch of the facial nerve and a branch of the internal maxillary artery.

## COSTEN'S SYNDROME COMPLEX

In any inflammation of the joint, it would be perfectly natural to expect this inflammation to affect the tissues in the space below the glenoid process. The plexus of nerves in this region would carry the pain or discomfort into the ears and surrounding regions. The origin of Costen's syndrome complex was undoubtedly due to some misconception of the anatomy of the temporomandibular joint. It is amazing how much subluxation in the joint would be required for the condyle to pass backward over the glenoid process and impinge on this tissue.

## RETRUSION OF THE MANDIBLE

I do not believe it is possible to retrude the mandible beyond the normal centric position, except by extreme pressure or a blow by which the joint is injured. Any boxer can testify that the resistance of the joint is sufficient to pass the effect of the blow on to the brain. However, it was not the purpose of this article to discuss the question of mandibular centric relation. I do know, however, that whenever the articulation or occlusion of the teeth did not conform to my definition of the centric relation (the most retruded position of the idle mandible), there was the characteristic untoward result.

9733 Willis Ave.
Sepulveda, Calif.

# HINGE AXES
## Part I. The Transverse Hinge Axis

DON N. BROTMAN, D.D.S.
*Baltimore, Md.*

THE MANDIBULAR HINGE AXIS THEORY was proposed well before 1930. Most of the associated information has been passed by word of mouth and, as a result, it is difficult to find basic information concerning the theory. This situation has indirectly encouraged many dentists to associate their knowledge and beliefs about hinge axis theory with their teachers. Thus, there are the Granger group, the Stuart group, the Transograph men, the Dentatus men, etc.

Unfortunately, many of these groups are "at war" with one another, either through personal differences among the leaders or lack of complete understanding of what the other groups are attempting to accomplish. If the existing animosity could be removed and the present knowledge coordinated and disseminated, the dental profession would benefit.

One means to this end would be the publication of comprehensive articles written so they could be understood by those who have had no background whatever in hinge axis theory. These articles should cover all facets of the hinge axis theory and the associated theories of articulation and occlusion. The dentist could then evaluate the subject matter for himself. This series of articles is an attempt in this direction; it is a discussion of the mandibular hinge axes and their clinical and geometric significance.

### THE TRANSVERSE HINGE AXIS

This discussion must be prefaced by the following question and answer. *How can we find a center of rotation for mandibular movements when we have been taught that as the mandible moves each condyle slides along the slope of its fossa?* The answer is that when we record a hinge axis or center of rotation for mandibular opening and closing, we guide the mandible in its most retruded path so that the condyles are not allowed to slide down their fossal slopes.

The hinge axis position of the mandible is the most retruded position of the mandible from which *opening and closing* movements can be made. When a mandible is opened and closed in hinge axis position, it is possible to locate a center of rotation—the transverse hinge axis (Fig. 1).

---

This is the first of a series of articles on this subject.

## LOCATING THE HINGE AXIS

The exact procedure used by the different "groups" in locating the transverse hinge axis varies slightly. Essentially, these are the procedures: (1) A tray (called a clutch) with a protruding stud is locked to the mandibular teeth with plaster (Fig. 2). (2) A hinge-bow (face-bow with adjustable arms) is attached to the stud (Fig. 3). (3) The dentist attempts to keep the mandible in the hinge axis position as the patient opens and closes the jaws. (4) The arms of the hinge-bow are adjusted so the pointers in front of the ears seem to stand still (only rotate), rather than move across the skin as the patient opens and closes the jaws in hinge axis position. (5) The points upon which the pointers stood still are marked on the skin of the sides of the face and are referred to as the hinge dots. The

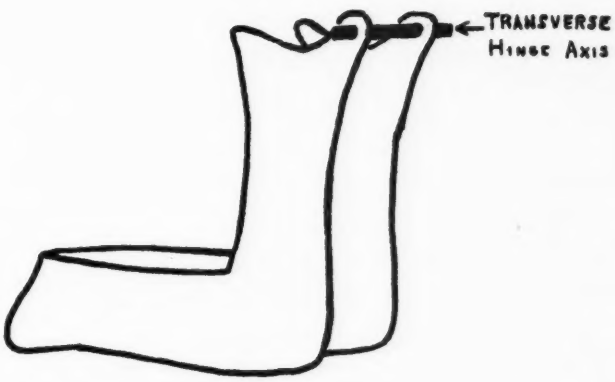



Fig. 1.—The transverse hinge axis is the line which goes through both condyles and is the center of rotation for the most retruded opening and closing path of the mandible.

markings may be made permanent by tatooing with a dye, or they may be temporary marks made with dye, ink, silver nitrate, or lipstick. Then, the hinge-bow and tray are removed from the patient.

The two hinge dots are stationary in relation to all fixed parts of the head and are in a constant relationship to the maxillary teeth. The maxillary cast can then be mounted on a hinge axis articulator in the same relationship to the opening and closing hinge of the articulator as the maxillary dental arch is to the opening and closing center of rotation of the mandible.

## MOUNTING THE CASTS

Wax is placed on a face-bow fork, and the patient is asked to close the teeth into the wax. This produces a shallow impression of the upper teeth, while the lower teeth stabilize the fork. The mandible need not be in the hinge axis position at this time since the lower teeth are acting only as stabilizers. The wax impression is removed from the mouth, placed on the maxillary cast, and tested for warpage by determining if the fork will rock, even slightly, on the cast.

The wax and fork are replaced on the patient's upper teeth and are once again stabilized by the lower teeth. The hinge-bow is attached to the stud of the face-bow fork and adjusted so that the positions of its pointers correspond to the positions of the hinge dots recorded earlier. An axis-orbital plane is located at this time, but this is not pertinent to this discussion of the transverse hinge axis. By means of a locking device, the apparatus connected to the fork is held rigidly in the relationship to which it has been adjusted and is removed from the mouth.

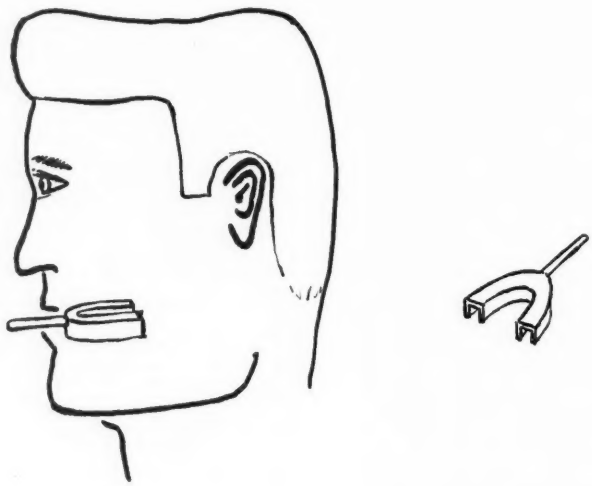


Fig. 2.—A tray (or clutch) is attached to the lower teeth with plaster.

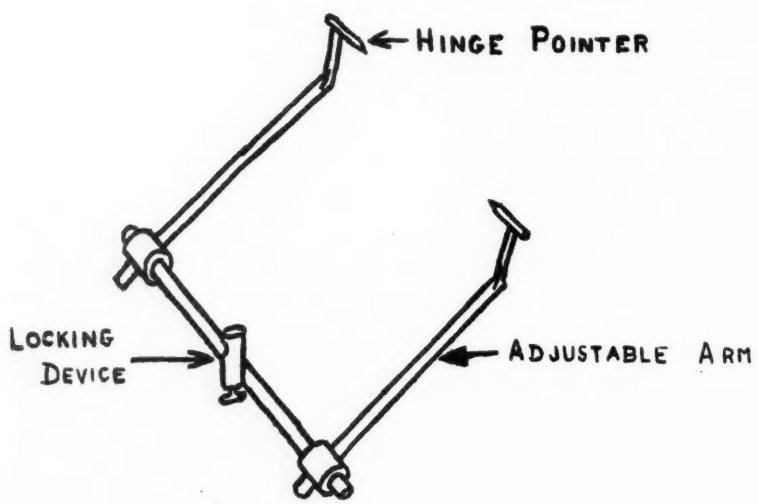



Fig. 3.—The hinge-bow is a variation of the arbitrary face-bow and is used to locate the transverse hinge axis. The hinge-bow is attached to the stud of the clutch and the arms are adjusted until the pins in front of the ears seem to stand still (only rotate) as the mandible is opened and closed *in its most retruded path.*

The opening and closing axis of the articulator is aligned with the hinge dot pointers. The maxillary cast is placed on the face-bow fork and the upper cast is mounted on the articulator, usually with artificial stone.

Interocclusal wax records of various thicknesses are made with the mandible in the hinge axis position (some call these interocclusal wax records "wax bites"). The mandibular cast is related to the upper cast by means of one of these records and is mounted on the articulator. The wax record used for mounting the lower cast is termed the "mounting record" (or *"bite"*).

Then an attempt is made to ascertain whether or not the mandible was *really* in the hinge axis position when the mounting record was made. The other records (termed "checking records" or "checking *bites"*) are introduced between the mounted casts to determine whether or not the casts fit into these records exactly the same as they fit into the mounting record. No movement of the articulator parts except simple opening and closing (necessary because of the thickness of the records) is acceptable. If three of the records fit accurately, we assume that the desired cast relationship has been recorded. Our assumption is based on the probability that the patient will be unable to produce exactly the same degree of protrusion at three different degrees of jaw separation. *Herein lies the value of the hinge axis registration.* We are able to determine accurately if our cast relationship is the desired one.

## CLINICAL APPLICATION AND SIGNIFICANCE

If the checking records do not match the original mounting, we separate the lower cast from the articulator and remount it to one of the checking records. Then, we repeat our checking procedures. The mandibular cast may have to be remounted many times before three records fit the mounting accurately and before we are satisfied that the cast relationship has been verified. Once it is ascertained that we have

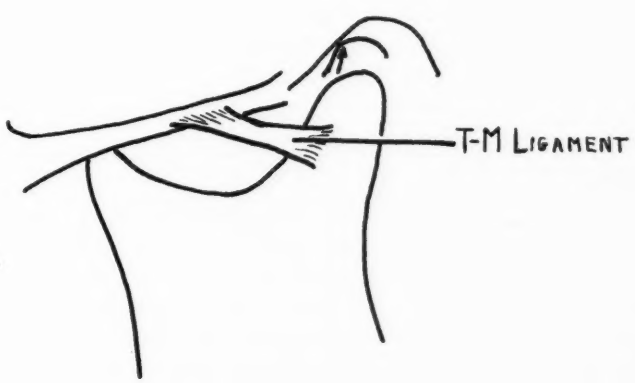



Fig. 4.—The temporomandibular ligament extends from the zygomatic arch to the neck of the condyle. This ligament cannot be stretched. When the mandible is guided in its most retruded path, the ligament guides the condyle upward against the anterior slope of the fossa (with the meniscus interposed).

an accurate mounting, the vertical space between the casts may be increased or decreased as much as 3 or 4 mm. without materially deviating from the cast's proper anteroposterior relationship. *If we do not verify the mounting of the lower cast, the time spent in locating the transverse hinge axis has been wasted.*

Anatomically, this is what occurred to the mandible when we located the transverse hinge axis and made the hinge records. The mandible was guided posteriorly until the temporomandibular ligaments were taut. These tightened ligaments caused the condyles to swing upward into contact with the anterior slopes of their respective fossae, with the menisci interposed (Fig. 4). Since the temporomandibular ligaments cannot be stretched under normal conditions and since the bony structures of the fossae and the condyles do not seem to change readily, the hinge axis position of the mandible is repeatable (barring pathologic change).

Whether or not the hinge axis position is the proper maxillomandibular relationship is not really known. Certainly, this arch relationship does not always exist in mouths with natural, healthy dentitions. Yet, for many years, fixed occlusal restorations have been built with the mandible in the terminal position corresponding to the hinge axis position, and these restorations have worked satisfactorily. Therefore, we must admit that the hinge axis position is a physiologically acceptable maxillomandibular relationship.

What occurs when we are not using a hinge axis type of articulator? First, there is no way to determine if the interocclusal record used to orient the lower cast to the upper one was made with the mandible in the proper position. Second, alteration of the vertical dimension on the articulator will affect the anteroposterior relationship of the casts in a manner which may be anatomically unacceptable and physiologically intolerable.

219 West Monument St.
Baltimore 1, Md.

# REGISTRATION OF THE CONDYLE PATH INCLINATION BY INTRAORAL WAX RECORDS: VARIATIONS IN THREE INSTRUMENTS

ULF POSSELT, L.D.S., ODONT. DR.,* AND GÖRAN FRANZÉN, L.D.S., M.K.**
*The Royal Dental School, Malmö, Sweden*

METHODS FOR RECORDING AND REPRODUCING sagittal condyle path inclinations on the articulator have been investigated critically. Some of the aspects discussed are: (1) intraoral versus extraoral jaw registration technique,[1,2,3] (2) the influence of the articulator design on the reproduction of the anatomic inclination of the condyle path (articulators of Hanau type versus the Arcon type[4-8]), and (3) the variation of condyle paths in dentulous subjects as recorded by the same person[9,10] and as recorded by different persons.[11]

The registration in the mouth and the adjustment and reading on the instrument must be differentiated. The making of the wax record in the mouth, instructions to the patient as to how to close the mouth, trimming of the wax record, etc., are all designated as "registration," and the registration is made by the dentist. The placing of the wax record between the casts, adjustment of the condyle paths, and the reading of the condyle inclination are designated as adjustment and "reading" on the instrument. Therefore, the end result (the value of the condyle path inclination) depends on a number of factors both during the registration and the reading.

Intraoral as well as extraoral methods have been criticized in connection with the construction of complete dentures,[3,12,13] where the resiliency of the mucosa may constitute a source of error. In natural dentitions, registration of the condyle path inclinations might be more exact. However, Craddock[9,10] found the variation of the condyle path inclinations for dentulous subjects to be far too great for any practical value.

Craddock's material covered 3 subjects with complete natural dentitions. He made three separate wax records in positions of various degrees of protrusion (edge to edge and 6 mm. of protrusion) for every subject. The registrations were made on a Hanau Model H articulator.

Nevakari[11] recorded and read sagittal condyle path inclinations on 7 persons with complete natural dentitions. He used a Brandrup-Wognsen articulator. Both the registration and the reading were carried out also by a second dentist. Due to the considerable variation of results obtained in the two series, Nevakari considers the results of the intraoral wax recording technique to be unreliable.

---

Translated and revised from Odontologisk Tidskrift 66:532-550, 1958, by permission of Dr. N. Sällström, editor.

*Head of the Department of Occlusal Analysis and Rehabilitation.
**Former demonstrator, the Department of Occlusal Analysis and Rehabilitation.

PURPOSE OF THE PRESENT INVESTIGATION

The main purpose of this investigation was to analyze variations in recording sagittal condyle path inclinations in dentulous subjects when recording was done by the same dentist.

The investigation was divided into two main parts: (I) The variation of condyle path inclination was recorded repeatedly by means of protrusive wax records read on the Dentatus articulator. Comparison was made with some of Craddock's[9,10] results. (II) A comparison was made of the variations in sagittal condyle path inclination with certain degrees of protrusion using the Dentatus and Bergström (1954 model) articulators and the Gnathothesiometer.[14]

SUBJECTS

The subjects were 11 men and 2 women dental students ranging from 22 to 27 years of age. In part I, 3 subjects were studied; in part II, 10 subjects were included.

None of the subjects had any temporomandibular joint symptoms or demonstrable alveolar bone resorption. Not more than two premolars and molars (except the third molars) were missing in any subject. At the most, only one tooth missing in one-half of the jaw and one 6-year molar missing in any subject were allowable.[15]

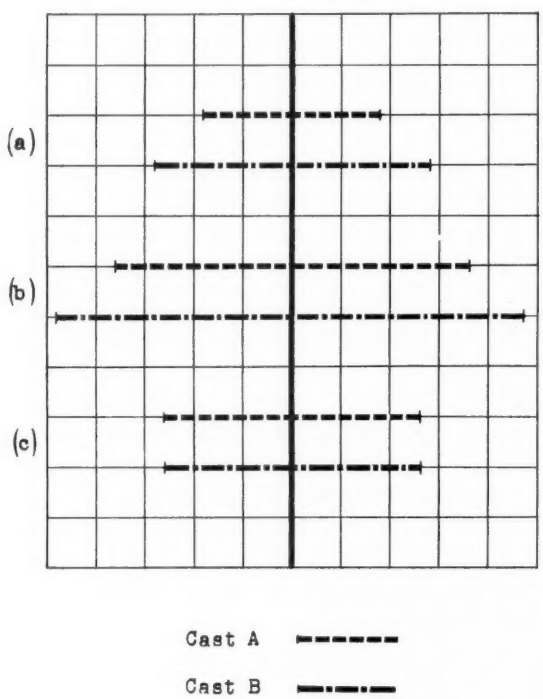



Fig. 1.—Standard deviation (subject 1) of casts A and B. *(a)* Not preformed, edge-to-edge position without contact between incisors. *(b)* Not preformed, edge-to-edge position during biting pressure. *(c)* Preformed, 4 mm. protrusion, incisors not in contact.

TABLE I. CONDYLE PATH INCLINATIONS (DEGREES) AND STANDARD DEVIATIONS

| SUBJECT | RECORDING METHOD | A | | | | B | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | LEFT | | RIGHT | | LEFT | | RIGHT | |
| | | M | SD | M | SD | M | SD | M | SD |
| 1 | a | 42.9 | 1.6 | 44.6 | 1.9 | 44.5 | 2.9 | 44.2 | 2.8 |
| | b | 36.5 | 3.6 | 45.4 | 3.6 | 41.1 | 6.3 | 44.7 | 3.1 |
| | c | 36.3 | 2.0 | 45.9 | 3.2 | 36.2 | 2.3 | 43.9 | 3.0 |
| 2 | a | 54.2 | 3.4 | 51.1 | 2.2 | 55.7 | 2.1 | 58.8 | 2.6 |
| | b | 55.5 | 3.0 | 53.0 | 2.7 | 56.9 | 2.1 | 54.5 | 3.1 |
| | c | 57.1 | 1.7 | 53.9 | 4.5 | 58.9 | 1.7 | 55.3 | 4.3 |
| 3 | a | 57.1 | 1.8 | 59.3 | 1.5 | 58.5 | 1.3 | 57.0 | 2.9 |
| | b | 55.3 | 4.7 | 57.2 | 2.0 | 58.4 | 1.7 | 57.7 | 1.9 |
| | c | 54.7 | 2.4 | 57.8 | 2.1 | 57.1 | 2.3 | 57.2 | 2.7 |

PART I

*Methods.*—Two impressions (A and B) of the upper and lower jaws were made in reversible hydrocolloid. All of the impressions and casts were made in the same material by the same dentist. Both of the upper casts were mounted with the same face-bow registration on the same articulator (Dentatus type *ARL*). The casts were orientated in relation to the axis-orbital (Frankfort) plane. The lower casts were mounted in the most posterior (terminal hinge) noncontact position.

The following records of protrusion were made by the same dentist for each subject: (a) 3 nonpreformed wax records in edge-to-edge position with no contact between the incisors, (b) 3 nonpreformed records in edge-to-edge position with biting pressure, and (c) 3 records preformed in the articulator with 4 mm. protrusion, with no contact between the incisors. Accordingly, a total of 9 records were made for every subject. A preformed protrusion record is one made in the Dentatus articulator after the two condylar balls have been retruded a certain number of millimeters by means of the bottom screws and the condyle path inclinations have been set at 30 degrees. The record is then corrected in the mouth and replaced in the articulator, after which the shift of the condyle balls is read on both sides.

This investigation was confined to protrusive records with moderate amounts of protrusion. Wax records supported on thin aluminum plates[16] were employed. The results were read independently by five different persons.

The mean and the standard deviation were calculated for the condyle path inclinations on each side for each series of records and for the casts A and B. Comparisons were made between the condyle path values obtained under different experimental conditions as well as between the results achieved with casts A and B (Fig. 1).

*Results.*—The mean and the standard deviation of the condyle path inclinations of both casts of the 3 subjects are given in Table I. The letters *a, b,* and *c* in the second column refer to the methods of obtaining the wax records described previously.

Statistical analysis showed no difference between casts A and B ($P > 5$ per cent).

Although the standard deviation appeared to be largest for the protruded position with biting pressure (Fig. 1, *b*), no significant difference was found between the condyle path values obtained with the protrusive records with and without biting pressure ($P =$ about 20 per cent). This was examined for subjects 2 and 3. No significant difference was found in the variations of the condyle path inclinations in edge-to-edge biting and with 4 mm. protrusion.

TABLE II. COMPARISON OF STANDARD DEVIATIONS WITH CRADDOCK'S RESULTS

| TYPE OF WAX RECORD | STANDARD DEVIATION | |
|---|---|---|
| | LEFT | RIGHT |
| Edge-to-edge position without contact (this investigation) | 2.5 | 2.6 |
| Incision unstrained (Craddock's investigation) | 4.0 | 5.2 |
| Wax records edge to edge with biting pressure (this investigation) | 4.3 | 3.0 |
| Incision strained (Craddock's investigation) | 3.0 | 4.3 |

Comparison of our measurements with those of Craddock is given in Table II.

The standard deviation of our measurements was thus somewhat less than in Craddock's, but it was still considerable (see Discussion).

Finally, we compared the values found for the condyle path inclinations obtained by five different examiners and noted a difference of 5 degrees (Table III).

TABLE III. MEANS AND STANDARD DEVIATIONS OBTAINED BY FIVE EXAMINERS AT THREE CONSECUTIVE READINGS USING THE SAME WAX RECORD*

| EXAMINER 1 | | EXAMINER 2 | | EXAMINER 3 | | EXAMINER 4 | | EXAMINER 5 | |
|---|---|---|---|---|---|---|---|---|---|
| M | SD | M | SD | M | SD | M | SD | M | SD |
| 52.4 | 4.5 | 53.0 | 3.9 | 54.7 | 3.2 | 53.7 | 4.8 | 57.3 | 1.8 |

*Subject 2, left condyle path, cast A, recording method a.

PART II

*The Problem.*—The relatively wide variation of the condyle path values might be explained by the difference in degree of protrusion from one time to another. It is possible that an increased amount of protrusion might give a narrower variation on repeated registrations. However, no difference was found in the degree of variation between the edge-to-edge position and the 4 mm. protrusion (preformed).

Thus, it was decided to investigate the extent to which the shift of the condylar shaft would influence the variation in the condyle path inclination. This was investigated systematically at 2, 4, 6, and 8 mm. of protrusion.

*The Influence of the Degree of Protrusion.*—It should be ascertained, first, whether or not the preformed amount of protrusion is maintained after the record has been corrected in the mouth. It was found that the true values for protrusion, read after registration in the mouth, deviated on the average by 0.2 mm. as compared with the preadjusted shifts of the condylar balls.

*Friction of the Condylar Mechanisms.*—Another possible explanation for the varying results is the "friction, clearance, and wear"[10] in the condylar mechanism. This mechanism in the Hanau type of articulator consists of a cylinder provided with a slot in which the condylar balls move (Fig. 2). The incline of this slot is determined by two different positions of each condylar ball—a central starting position and an eccentric position which the condylar ball is made to assume. Friction

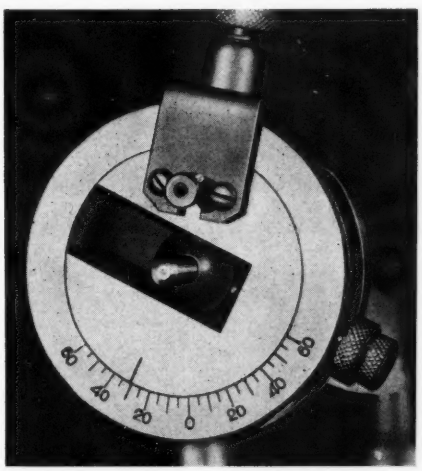



Fig. 2.—The condylar mechanism of a Dentatus articulator.

between the condylar cylinders and the top part of the condylar pillars may influence the reliability of the values obtained for the inclinations. The possible influence of this factor can be investigated by comparing three different instruments whose "condylar mechanisms" differ in this respect.

In Bergström's articulator[4,5] the condyle path inclination is determined on each side by an adjustment of a plate (Fig. 3). The plate can be rotated until it comes into contact with the shaft rods on either side. The Gnathothesiometer[14] was also used in the investigation (Fig. 4). The condylar shaft of this instrument assumes its positions without the movement of surfaces which develop friction (Fig. 5).

*Methods.*—Impressions were made with reversible hydrocolloid of the dental arches of 10 subjects. Three models of the original cast were made in a "Korogel" mold and mounted by the same person on three different instruments with respective face-bows. The casts were mounted with the occlusal plane horizontal.

Six preformed wax records with protrusive displacements of 2, 4, 6, and 8 mm. were made for each of the 6 subjects. Thus, 24 records were obtained for all.

*Statistical Analysis and Results.*—The statistical analysis was carried out in three stages. A sample comprising 4 subjects was analyzed first. Apart from certain differences between the instrument and the degree of protrusion (Fig. 6), the differences between the readers were not significant.

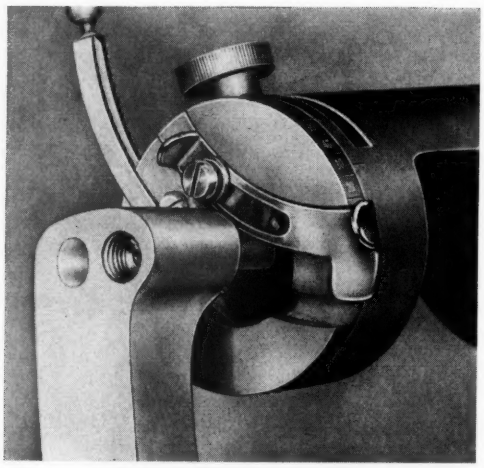


Fig. 3.—The condylar mechanism of the Bergström articulator.

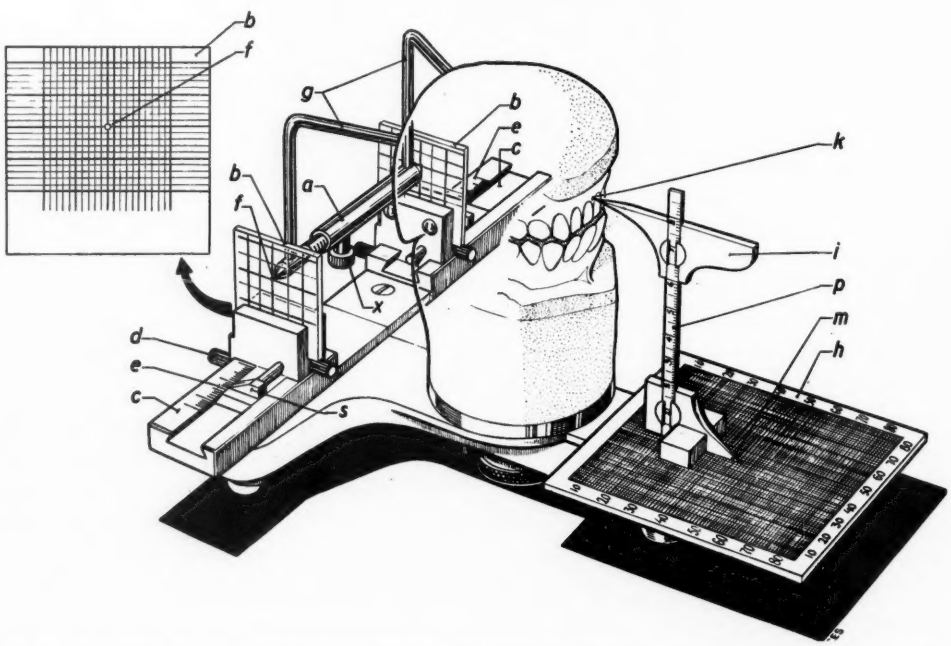



Fig. 4.—The Gnathothesiometer is an instrument used for three-dimensional registration of the positions of the lower jaw.

In order to judge the differences between instruments and degrees of protrusion, the number of subjects was increased to 10. The material was analyzed regarding the different instruments and the various degrees of protrusion. A strong covariation between these factors could be shown to exist. The instruments and the degrees of protrusion showed significant differences among themselves. The differences between the instruments were not sufficiently large to be definitely differentiated from the covariation between the instrument and the degrees of protrusion. However, this was possible with the differences between the various degrees of protrusion.

Since the values for 2 mm. of protrusion showed a definitely different order of magnitude of variation than the others, the 2-mm. records were neglected and a closer analysis was made of the remaining material. The Gnathothesiometer showed a marked difference when compared with the two articulators. A less marked difference, but still a statistically significant one, was found between the Dentatus and Bergström articulators.

No significant difference was found between 8 mm. of protrusion versus that of 6 and 4 mm., but 6 mm. of protrusion differed significantly from 4 mm. The reliability of these closer analyses diminishes because of the considerable covariations existing between the instruments and the degrees of protrusion. The analyses of the amounts of protrusion are less reliable than those of the instruments.

The means and standard deviations for the instruments and the degrees of protrusion are seen in Table IV. The unreliability of a single observation on the

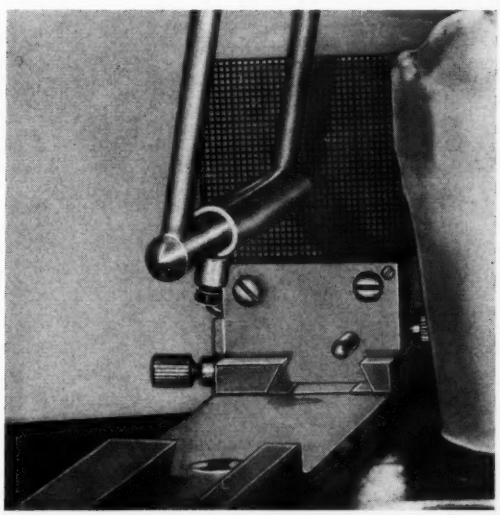


Fig. 5.—The condylar shaft of the Gnathothesiometer.

Gnathothesiometer is larger than with the other instruments, although the sensitivity for readers and condyle path inclinations is lower than with the other instruments.

The Gnathothesiometer gives on the average somewhat higher values of the condyle path inclination than the other instruments. Concerning the amount of

TABLE IV. MEANS AND STANDARD DEVIATIONS* BY INSTRUMENTS AND DEGREES OF PROTRUSION

| AMOUNT OF PROTRUSION | DENTATUS ARTICULATOR | | | BERGSTRÖM ARTICULATOR | | | GNATHOTHESIOMETER | | | OVER-ALL AVERAGE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | SD | | M | SD | | M | SD | | M | SD | |
| | | ERROR† | SENSITIVITY‡ | | ERROR | SENSITIVITY | | ERROR | SENSITIVITY | | ERROR | SENSITIVITY |
| 2 mm. | 23.3 | 5.9 | 25.9 | 20.6 | 4.9 | 24.9 | 31.4 | 7.8 | 16.4 | 25.1 | 6.3 | 25.3 |
| 4 mm. | 30.1 | 2.5 | 20.8 | 20.8 | 2.5 | 18.2 | 33.7 | 3.7 | 9.2 | 30.9 | 3.0 | 17.4 |
| 6 mm. | 30.9 | 2.0 | 17.2 | 32.0 | 2.4 | 15.1 | 33.9 | 3.2 | 7.0 | 32.3 | 2.6 | 14.1 |
| 8 mm. | 30.0 | 2.3 | 15.6 | 32.3 | 2.1 | 13.0 | 33.0 | 2.7 | 5.9 | 31.7 | 2.3 | 12.5 |
| Average of all | 28.6 | 3.5 | 21.4 | 28.4 | 3.2 | 21.5 | 33.0 | 4.8 | 10.6 | 30.0 | 3.9 | 19.3 |
| Over-all average when 2 mm. has been eliminated | 30.3 | 2.3 | 17.9 | 31.0 | 2.3 | 15.9 | 33.5 | 3.2 | 7.5 | 31.6 | 2.6 | 14.8 |

*Condyle path inclination in 10 subjects.
†Error of the single observation.
‡Sensitivity partly for examiner (difficulty in reading the instrument) and partly for different condyle path inclinations.

protrusion, 2 mm. differs markedly from the other amounts of protrusion. At 2 mm. of protrusion, lower values of the condyle path inclination are obtained. However, the standard deviation regarding the unreliability of a single observation, as well as the sensitivity for different readers and different condyle path inclinations, is larger. The standard deviation always diminishes as the degree of protrusion increases.

A correlation analysis was made to obtain further information concerning the differences between the instruments and the amounts of protrusion. This analysis was made up of the condyle path inclination of the left condyle in 10 subjects as

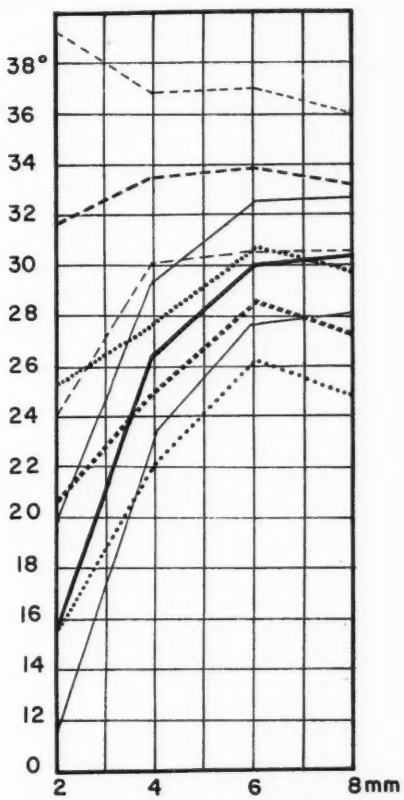



Fig. 6.—Graphic presentation of condyle path inclinations at different degrees of protrusion. The means of the three instruments are indicated by thick lines; the standard deviations of each instrument are indicated by thin lines. . . . . ., Dentatus; ————————, Bergström; – – – – – – – – – –, Gnathothesiometer. The material represents 4 persons.

recorded at four different amounts of protrusion with three different instruments. The reliability of each record of the condyle path inclination was based on two readings on six different wax records. Thus, part of the primary material was omitted and the rest was compressed in order to obtain a single but more reliable expression of the condyle path inclination for each subject, amount of protrusion, and instrument.

The analysis on the different instruments appears in Table V, which shows the correlation coefficients, and is illustrated to a certain extent by Fig. 7.

The data show that the Dentatus and Bergström articulators have greater connection with each other than with the Gnathothesiometer, and any difference concerning the correlation with the Gnathothesiometer cannot be shown between the Dentatus and the Bergström instruments.

TABLE V. CORRELATIONS BETWEEN THREE DIFFERENT INSTRUMENTS

| AMOUNT OF PROTRUSION | CORRELATION COEFFICIENTS | | |
|---|---|---|---|
| | DENTATUS-BERGSTRÖM | DENTATUS-GNATHOTHESIOMETER | BERGSTRÖM-GNATHOTHESIOMETER |
| 2 mm. | 0.8 | 0.1 | 0.1 |
| 4 mm. | 0.5 | 0.5 | 0.4 |
| 6 mm. | 0.8 | 0.7 | 0.6 |
| 8 mm. | 0.8 | 0.3 | 0.4 |
| Σ | 0.8 | 0.3 | 0.3 |

TABLE VI. SENSITIVITY PARTLY FOR EXAMINERS (DIFFICULTY IN READING) AND PARTLY FOR DIFFERENT CONDYLE PATH INCLINATIONS BASED ON THE TOTAL MATERIAL

| AMOUNT OF PROTRUSION | INTERCLASS VARIANCE (SD) | | |
|---|---|---|---|
| | DENTATUS-BERGSTRÖM | DENTATUS-GNATHOTHESIOMETER | BERGSTRÖM-GNATHOTHESIOMETER |
| 2 mm. | 25.9 | 24.9 | 16.4 |
| 4 mm. | 20.8 | 18.2 | 9.2 |
| 6 mm. | 17.2 | 15.1 | 7.0 |
| 8 mm. | 15.6 | 13.0 | 5.9 |
| Σ | 21.4 | 21.5 | 10.6 |

TABLE VII. SENSITIVITY FOR DIFFERENT CONDYLE PATH INCLINATIONS BASED ON THE CORRELATION ANALYSIS MATERIAL

| AMOUNT OF PROTRUSION | INTERCLASS VARIANCE (SD) | | |
|---|---|---|---|
| | DENTATUS-BERGSTRÖM | DENTATUS-GNATHOTHESIOMETER | BERGSTRÖM-GNATHOTHESIOMETER |
| 2 mm. | 35.2 | 38.8 | 21.5 |
| 4 mm. | 16.9 | 26.4 | 11.4 |
| 6 mm. | 20.9 | 23.1 | 8.8 |
| 8 mm. | 20.3 | 20.6 | 8.5 |
| Σ | 26.0 | 31.5 | 13.4 |

Through the correlation analysis, a basis was obtained on which a supplementary parallel to Table IV could be built concerning the sensitivity of the instrument. The analysis on the sensitivity for the examiners is seen in Table VI and that for the different condyle path inclinations in Table VII.

## DISCUSSION

The purpose of the investigation was to clarify the influence of the amount of protrusion and the construction of the apparatus on the range of variation of the condyle path inclination in a given person under as well-controlled conditions as possible. In part I, the same face-bow registration was used. The results for double mountings of 3 subjects did not appear to influence the results appreciably. Thus, the influence of the error in the face-bow registration[17,18] can be regarded as negligible.

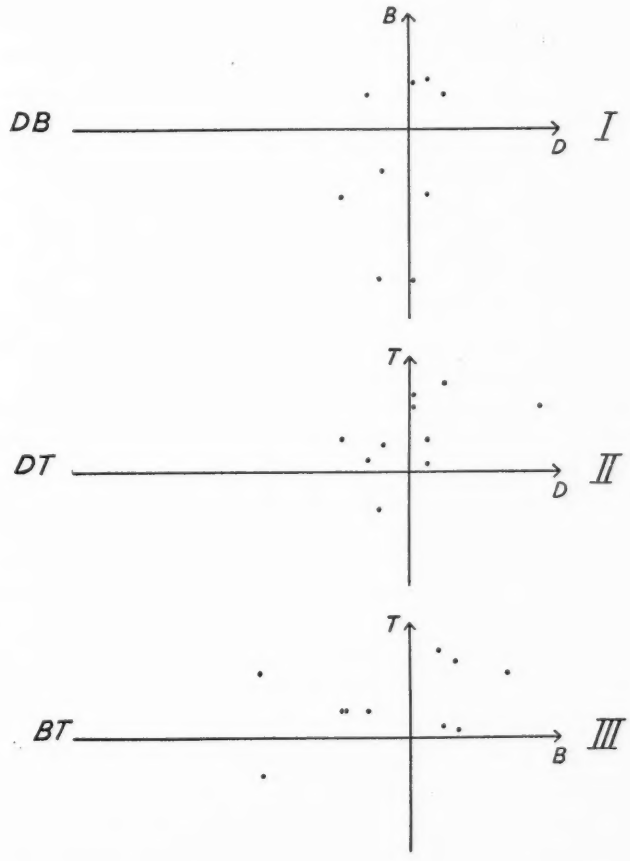



Fig. 7.—The interrelation between the three different instruments. The correlation as plotted for the inclination of the left condyle path at 4 mm. protrusion is illustrated on three coordinate systems. *I*, The abscissa represents Dentatus; the ordinate, Bergström. *II*, The abscissa is Dentatus; the ordinate, Gnathothesiometer. *III*, The abscissa is Bergström; the ordinate, Gnathothesiometer.

Comparison between the standard deviations as calculated from our material and those given by Craddock[9] showed that ours were somewhat less, even though we studied more material and could thus tolerate a somewhat larger standard deviation. This may be because the retruded position was used for the mounting of our casts, while Craddock used the occlusal (intercuspal) position. At the edge-to-edge biting position, however, it is improbable that such a small difference between the two mounting positions would have any effect. The difference between the standard deviations found by Craddock[9] and those obtained in our investigation might also be due to the wax record technique. Delicate wax records might be trimmed without deformation when stiffening plates are used, but an error may be introduced without the use of these plates. The absolute inclination values in this connection are only of importance in relation to the results obtained in the same series of the investigation.

It may be concluded that the condyle path inclination cannot be determined by intraoral wax records without a fairly wide variation, independent of the type of apparatus employed. This variation does not appear to depend on friction from the metal condylar mechanisms, because the Gnathothesiometer shows even greater variations.

The following explanation is suggested for this relatively wide variation in the three instruments used. A wax record, theoretically, completely defines the jaw relationships. When an interocclusal relationship of casts is fixed by a wax record, the position of all of the other points on or in integral connection with the movable cast is determined. Two points on the intercondylar shaft, for example, may be determined three dimensionally, provided that the casts can be fixed firmly in relation to one another. A small tipping of the casts must produce a disproportionately large displacement of the points in the condylar region, and this displacement increases with the distance between these points and the dentition.

In addition, when adjusting the articulator, pressure against the cast may cause a discrepancy. Even a slight change in the point of application of the pressure is sufficient to produce a tipping effect, which is readily demonstrable by registration of the condyle path inclination on the articulator. Discrepancies can also occur because of the resiliency of the wax.

## CONCLUSIONS

The amount of protrusion should be 6 to 8 mm. for mechanical reasons. Physiologically, 2 mm. should be the most suitable distance, but the variation with this amount of protrusion was found to be about twice as large as with the others. Practically, a compromise between that desirable from a physiologic point of view and that mechanically possible suggests that 4 mm. of protrusion is suitable.

It appears that the variation is caused mainly by the wax record. The wax record method, which theoretically approaches the ideal, appears to be difficult to apply with precision in practice.

Another question is whether the variation is so large that registration by an intraoral wax record is meaningless. As will be discussed in a future article, the error of the method is not so large that different actual values of condyle path

inclinations cannot be distinguished. From that viewpoint, the wax registration is not meaningless.

We agree with Beyron[19] that a person trained in the maxillomandibular registration technique obtains considerably better results than an untrained person. This question was not examined in this article, but the examining dentists had had considerable experience with the technique.

Whether an adjustment of the condyle path inclination is meaningless with regard to the shortness of the path during tooth-to-tooth contact in function is quite another matter. The question cannot be answered in general, because several factors influence the decision. Among these are the way the articulator is used in the investigation and the way the restoration is to be made.

## SUMMARY

It has been asserted that intraoral registration of the condyle path inclination is so inexact that the method is of no practical value.

We repeated some of Craddock's measurements using 3 subjects with complete or practically complete natural dentitions. We found a slightly smaller standard deviation than he did. Attempts were made to keep the face-bow registration and the mounting as uniform as possible. A comparison of double mountings of 3 subjects showed no statistical difference in the paired values.

The differences found between different amounts of protrusion were analyzed for the single instrument and, also, in different instruments (the Dentatus and Bergström articulators and the Gnathothesiometer). This analysis was based on 10 subjects. The variations were found to be relatively large for all amounts of protrusion with all three instruments.

Since the variation between instruments and amounts of protrusion is large, the reliability of a statistical analysis diminishes. However, it was possible to ascertain the following: (1) The values for 2 mm. protrusion are of an entirely different order of magnitude than those of the other amounts of protrusion. (2) The Dentatus and the Bergström articulators showed relatively good accordance with each other. (3) The unreliability of a single observation on the Gnathothesiometer is larger than for the other instruments, but the sensitivity for the readers (the difficulty of reading) and for the condyle path inclinations is lower.

The main cause of the relatively large range of variation with the intraoral wax record technique is in the nature of the registration. The detail of a relatively small surface determines the positions of fairly distant points.

## REFERENCES

1. Gysi, A.: Beitrag zum Artikulationsproblem, Berlin, 1908, A. Hirschwald Verlag.
2. Hanau, R.: Full Denture Prosthesis, Intraoral Technique for Hanau Articulator, Model H, ed. 4, Buffalo, N. Y., 1930, Hanau Engineering Co.
3. Narbe, S., and Årstad, T.: Olika metoder att registrera underkäkens rörelser vid helproteskonstruktion, en översikt och kritik, Odont. revy **1**:38-57, 1950.
4. Beck, H. O., and Morrison, W. E.: Investigation of an Arcon Articulator, J. Pros. Den. **6**:359-372, 1956.
5. Bergström, G.: On the Reproduction of Dental Articulation by Means of Articulators, Acta odont. scandinav. **9**:suppl. 4, 1-149, 1950.

6. Christensen, F. T.: Kjeveleddvinkelens forhold ved bittförändringer på kraniet og i artikulator, og dets betydning *for the check bite,* Odont. tskr. **56**:392-408, 1948.
7. Palmqvist, O.: Några synpunkter på kondylbaneregistreringen i artikulator av Hanau-typ, Svensk tandläk.-tskr. **42**:88-97, 1949.
8. Palmqvist, O.: Kondylbaneregistrering medelst protrusionsindex-en artikulatorundersökning, Svensk tandläk.-tskr. **43**:217-230, 1950.
9. Craddock, F. W.: The Accuracy and Practical Value of Records of Condyle Path Inclination, Thesis, Northwestern University Dental School, 1948.
10. Craddock, F. W.: The Accuracy and Practical Value of Records of Condyle Path Inclination, J.A.D.A. **38**:697-710, 1949.
11. Nevakari, K.: Sagittaalisen leukanivelradan yksilöllisen kaltevuuden määrittämistarkkuudesta intraoraalista vahnaindeksitekniikkaa käyttäen. Om kondylbaneregistreringens exakthet vid den intraorala vaxindexmetoden, Finska tandläk.-sällsk. förhandl. **53**:205-212, 1957.
12. Holzmann, W.: Die interokklusale Gelenkbahnmessung nach der Methode von Christensen in Verbindung mit dem Artikulator von Hanau, Schweiz. Monatschr. Zahn. **37**:1-50, 1927.
13. Müller, M.: Unerwartete Ergebnisse des mathematischen Untersuchung des Christensenschen Phänomenes. Ueber negative Gelenkbahnen, Deutsch. Zahn. Wchnschr. **31**:673-685; 729-745, 1928.
14. Posselt, U.: An Analyzer for Mandibular Positions, J. Pros. Den. **7**:368-374, 1957.
15. Posselt, U.: Studies in the Mobility of the Human Mandible, Acta odont. scandinav. **10**: suppl. 10, 1-160, 1952.
16. Posselt, U.: En vaxindexteknik vid tandförsedda fall, Svensk tandläk.-tskr. **44**:337-343, 1951.
17. Åkerlund, O., and Öberg, T.: En orienterande undersökning av de tillfälliga felens storlek vid inslagning i artikulator för helprotesfall med ansiktsbåge av typ Hanau, Svensk tandläk.-tskr. **46**:107-120, 1953.
18. Åkerlund, O., and Öberg, T.: En undersökning av de tillfälliga felens storlek vid inslagning i artikulator för tandförsedda fall med ansiktsbåge av typ Hanau. Svensk tandläk.-tskr. **48**:99-108, 1955.
19. Beyron, H.: Det adulta bettet och bettanalys, Nord. klin. odont. **2**:1-32, 1958.

The Royal Dental School
Malmö S, Sweden

# A COMPLETE DENTURE TECHNIQUE FOR SELECTING AND SETTING UP TEETH

LUCIAN G. COBLE, D.D.S.*
*Greensboro, N. C.*

THIS ARTICLE DESCRIBES my technique for mounting casts on the articulator and selecting and arranging teeth. By this stage, the impressions have been completed and the casts poured.

## OCCLUSION RIMS

The upper occlusion rim is cut to the length of the upper lip, and the occlusal surface in the bicuspid region is made parallel to an imaginary line through the pupils of the eyes. The lower occlusion rim is constructed to a thickness of about three layers of the baseplate wax. The wax that extends over the retromolar pad is trimmed to the apex of the pad. A handle about ½ inch wide and ¼ inch thick is added to the anterior part of the lower occlusion rim (Fig. 1).

## ESTABLISHING VERTICAL DIMENSION

The patient says *m* several times with the upper occlusion rim in the mouth, and a measurement is made with the lip gauge from the labionasal angle to some point on the chin (Fig. 2). The lower occlusion rim is placed in the mouth, and the handle is reduced until the previous measurement is obtained when the rims are in contact. The patient says *55–55–55,* and the lips are observed to determine if the length of the teeth, as indicated by the length of the occlusion rims, will look good for this individual. The word "fifty" raises the upper lip, and "five" lowers the lower lip. The midline of the occlusion rims is made clearly visible by dipping a wet finger into dry plaster and rubbing it across the line (Fig. 3).

## ESTABLISHING CENTRIC RELATION

Four notches are cut into the upper occlusion rim in the molar regions, and the lower occlusion rim is built up directly under these notches with very soft wax. The patient raises his tongue and closes his mouth in centric relation (Fig. 4). The wax is allowed to harden slightly, then the upper cast is mounted on the articulator with a mounting jig (Fig. 5). The articulator is inverted while resting on the stand (Fig. 6) or the hot plate, and the lower cast is mounted.

---

Presented before the Greater New York Dental Meeting, New York, N. Y.
*Clinical Professor of Prosthodontics, The University of North Carolina, School of Dentistry.

Fig. 1.

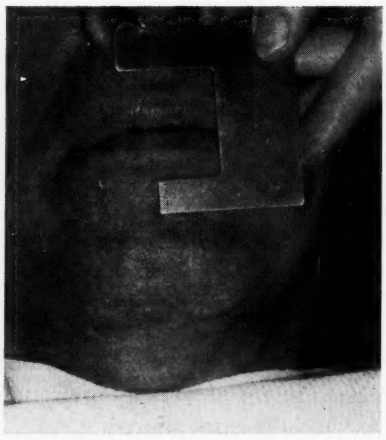


Fig. 2.

Fig. 1.—The lower occlusion rim is constructed with an anterior wax handle, which is used in establishing the vertical dimension of occlusion.

Fig. 2.—A lip gauge is used to make external measurements.

Fig. 3. Fig. 4.

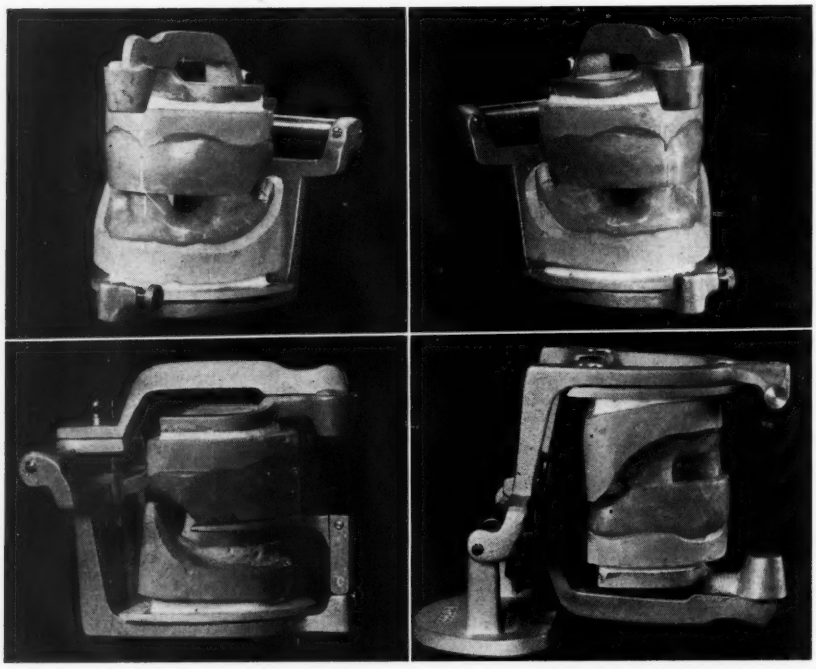


Fig. 5. Fig. 6.

Fig. 3.—The midline of the occlusion rims is marked with dry plaster of Paris in the grooves.

Fig. 4.—The casts are mounted on the articulator.

Fig. 5.—The upper cast is mounted on the articulator with a mounting jig.

Fig. 6.—The articulator is inverted to mount the lower cast.

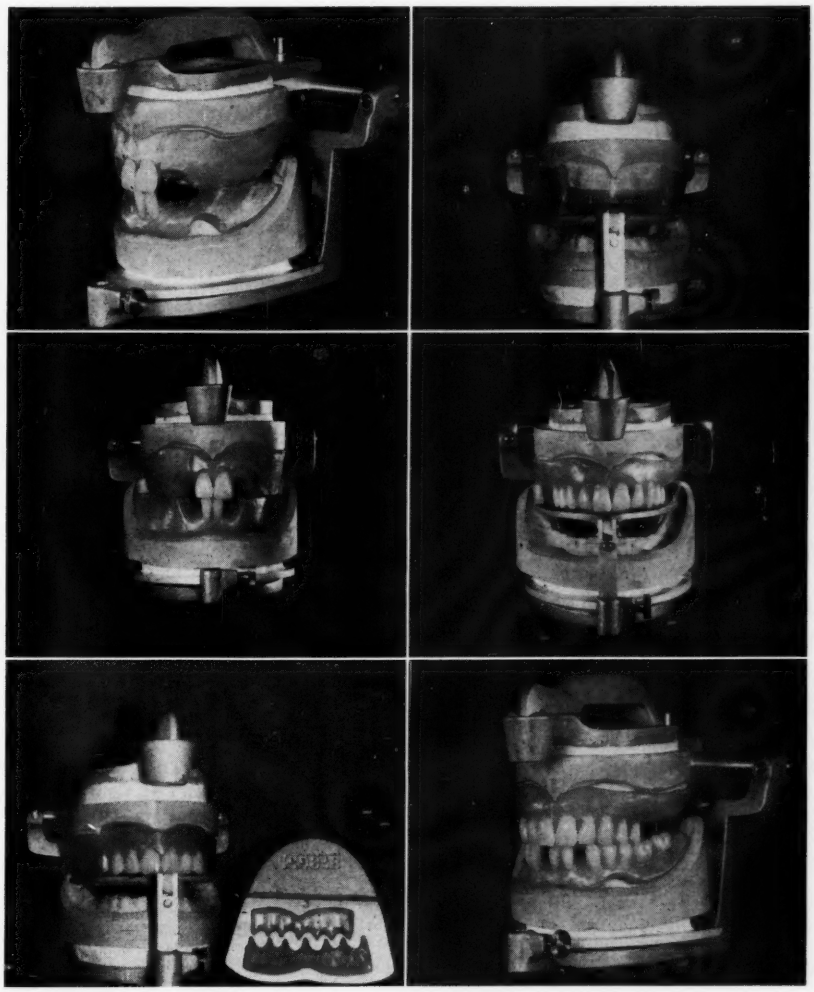


Fig. 7.—The Coble Balancer is mounted on the occlusion rims.

Fig. 8.—The wax is removed from the labial surface of the upper occlusion rim, so the cast is the guide in selecting the teeth.

Fig. 9.—The upper and lower central incisors are set in the occlusion rims, and the correct labiolingual inclination for expression is developed.

Fig. 10.—The upper anterior teeth touch the mounting jig, except for the incisal edges of the lateral incisors, which are 0.25 mm. short of the mounting jig.

Fig. 11.—Labial wax veneers are made in a metal form.

Fig. 12.—The posterior teeth are arranged to allow sufficient tongue space and to create the correct tooth-ridge relationship.

The centric relation mounting must be verified. To do this, the bridge of a Coble Balancer is heated and placed on the lower occlusion rim and the articulator is closed (Fig. 7). The centering ring is placed on the lower bridge and the tracing pin in the ring. With a cone of softened modeling compound on the tracing pin, the articulator is closed and the modeling compound is chilled. A graph plate is placed on the bridge and the patient develops a Gothic arch tracing. The occlusion rims are returned to the articulator, and if the pin rests on the apex of the tracing on the bridge, the centric relation record has been verified.

### SELECTING THE TEETH

With the mounting jig on the articulator, the wax is cut from the upper occlusion rim, exposing the ridge of the cast from cuspid to cuspid (Fig. 8). The size of the ridgelap and bite of the teeth to be selected are determined by the thickness of the wax. Two different sizes of teeth that are in harmony with the facial form are selected. The teeth are arranged on the occlusion rim and tried in the mouth to determine if the larger tooth or the smaller tooth should be used.

### ARRANGING THE TEETH

After the teeth have been selected, the upper and lower central incisors from the mold guide are set in the occlusion rims (Fig. 9). The rims are placed in the mouth, with a graph plate on the bridge, and the patient moves the jaw forward and back and side to side. In this manner, the amount of vertical overlap for this individual is determined.

All upper anterior teeth except the lateral incisors are arranged so they touch the mounting jig. The incisal edges of the lateral incisors are 0.25 mm. short of the mounting jig (Fig. 10). Softened baseplate wax is pressed in the occlusion rim form (Fig. 11) to develop a labial wax veneer. The veneer is placed from cuspid to cuspid to form the upper labial surface of the labial flange.

The lower teeth are arranged so that the lower bicuspids must be set just off the ridge, in order that they will not crowd the tongue (Fig. 12). The lower molars must be placed directly over the ridge, in such a way that the fossae are on a line passing through the center of the retromolar pad. Then, the upper molars are set with the proper cusp and fossa relationship to the lower molars. Their position with respect to the ridge is not so critical as that of the lower molars.

The last procedure is the selection of lower anterior teeth that will suit the space that is left. These teeth may be of different size than those carded with the set of upper teeth.

Suite 330
Jefferson Standard Bldg.
Greensboro, N. C.

# PHYSICAL FACTORS RELATED TO DENTURE RETENTION

R. G. Craig, Ph.D.,* G. C. Berry, M.S.,** and F. A. Peyton, D.Sc.***
*University of Michigan, School of Dentistry, Ann Arbor, Mich.*

The retention of a complete denture may be influenced by a number of variables arbitrarily classified by Hardy and Kapur[1] as physical, physiologic, psychologic, mechanical, and surgical in character. The physical classification involves such forces as adhesion, cohesion, capillarity, and/or atmospheric pressure. The nature of the supporting tissue, the patient's neuromuscular control, ridge characteristics, and related considerations are included in the physiologic category. The intelligence, expectation, apprehension, and gagging of the patient are listed as psychologic; occlusion, leverage, and shape are mechanical factors. Surgical ridge extension and implantation of dentures are in the surgical classification.

This wide variety of factors emphasizes the complexity of the problem of separating, measuring, and assigning a relative order of importance to any specific factor, particularly if retention measurements are made using a denture and a patient. Snyder and associates,[2] Östlund,[3] Skinner and co-workers,[4,5] and Campbell[6,7] investigated the force required to dislodge dentures from patients or models. These authors examined the effect of reduced pressure, the choice of denture-base material, denture design, the effect of water sorption of the denture base, and the role of the fluid film on the retention of dentures. DeVan,[8] Moses,[9] Lammie,[10] and Terrell[11] have presented clinical evidence relating the techniques of denture construction to retention. Cox[12] and Stanitz[13] have presented a physical or mathematical treatment of surface tension forces, atmospheric pressure, and adhesion forces and their relationships to denture retention.

In spite of these research efforts, considerable confusion exists regarding the physical factors involved in denture retention. The retentive force has been attributed to capillarity, adhesion, reduced pressure in the saliva film, atmospheric pressure, and other factors.

An equation has been developed in surface chemistry which relates the force required to separate two parallel plates with an intervening liquid film. This may

---

Read before the American Academy for Plastics Research in Dentistry, Chicago, Ill.
A portion of the financial support of this study was provided by the Jectron Company, Toledo, Ohio.

*Assistant Professor of Dentistry.
**Laboratory Technician.
***Professor of Dentistry.

be considered to be a simplified simulation of a denture base against the oral tissues. The equation, which assumes that the force is entirely due to capillary attraction, is

$$F = \frac{2 \gamma A \cos \theta}{dg}$$

The separating force *(F)* is related to the surface tension of the liquid film ($\gamma$), the area of the solid surfaces *(A)*, the contact angle that the liquid makes with the solid ($\theta$), the thickness of the film *(d)*, and the gravitational constant *(g)*.

This equation may be used to establish how much of the separating force attributable to capillarity is required to pull apart a disk of denture-base material and glass with a film of saliva interposed. This is accomplished by calculating the separating force from determined values of the surface tension of saliva, the area of the disks, the contact angle, and the thickness of the film. The separating force also may be determined experimentally. A comparison of the calculated and experimental values should indicate the importance of capillarity in retention. If the calculated and experimental values agree, the force holding the plates together is caused by capillarity. If the experimental separating force is greater than the calculated value, some other factor in addition to capillarity is operating.

Thus, the purposes of this study were (1) to measure the contact angles of saliva on polymethyl methacrylate and polystyrene denture-base materials, (2) to determine the surface tension of saliva, (3) to determine the film thickness, (4) to measure the forces required to separate the denture-base material from a glass surface with a saliva film interposed, and (5) to compare the experimental and calculated separating forces.

## MATERIALS AND METHODS

Heat-cured polymethyl methacrylate and polystyrene (Jectron) dental plastics were used in this investigation.

*Surface Tension Measurements.*—Human saliva samples were collected by having patients chew paraffin wax. Saliva collected after the first 100 ml. was used in these experiments. The surface tension determinations on saliva were made on a du Noüy Tensiometer[14] at room temperature. The values varied from 53.4 to 57.0 dynes per centimeter. Samples collected immediately before or between meals were found to be more viscous and lower in surface tension than saliva collected immediately after a meal. In order to establish a basis for comparison, the surface tension of 25° C.–distilled water was determined and was found to be 72.3 dynes per centimeter.

*Contact Angle Measurements.*—If a small amount of liquid placed on a solid surface does not spread, it forms a drop. The angle that this drop makes with the surface is an indication of the interaction or adhesion between the solid and liquid. The larger the angle, the less the adhesion. A liquid drop forming an angle ($\theta$) on a solid surface is represented in Fig. 1.

The contact angles for distilled water and saliva on the plastic surfaces were determined by using a shadow box technique. A diagram of the equipment is shown in Fig. 2. Typical examples of photographs of the contact angles for saliva

on polystyrene and polymethyl methacrylate denture-base materials are shown in Fig. 3. These angles were measured with the periphery of the drop in contact with the clean, solid surface and are called advancing contact angles ($\theta_a$). If a portion of the liquid drop is withdrawn until the periphery of the drop decreases, the edge of the drop is in contact with a film of liquid on the solid. The angle is designated

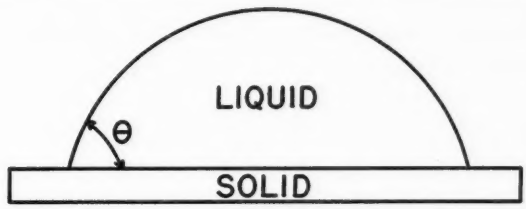



Fig. 1.—A liquid drop forms a contact angle ($\theta$) on a solid surface.

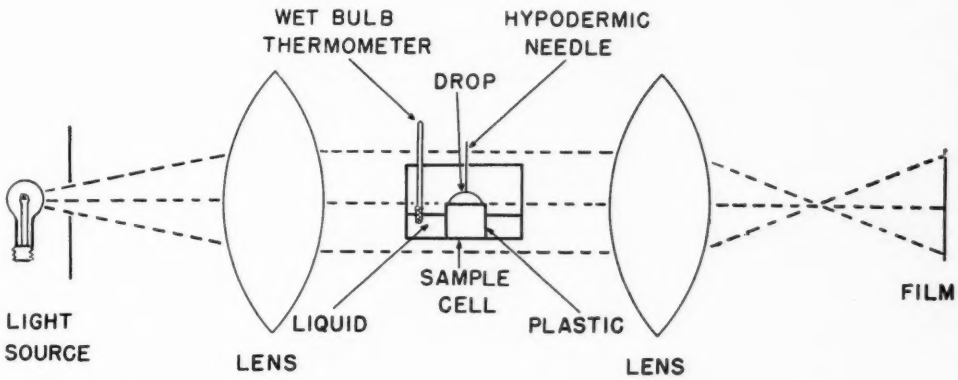
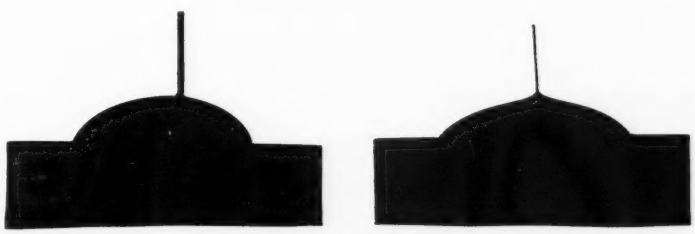



Fig. 2.—The design of the equipment used for measuring contact angles.



*A.* *B.*

Fig. 3.—The advancing contact angles of saliva on polystyrene *(A)* and on polymethyl methacrylate *(B)*.

as a receding contact angle ($\theta_r$), and it is often smaller than the advancing angle. This decrease results from differences in adhesion between the liquid drop and the solid and the liquid drop and the liquid film. Both angles are important, but from the standpoint of retentive force measurements, the receding contact angle is much

more important. This is because the saliva film between the denture base and the tissues recedes over these surfaces during the dislodgment of a denture. The receding contact angle, therefore, is the angle needed to substitute in the preceding equation.

The size of the drop may be adjusted by use of a hypodermic syringe to determine the advancing and receding angles. Once the desired drop size is attained, it is maintained without change because the air in the sample cell is saturated with the vapor of the liquid.

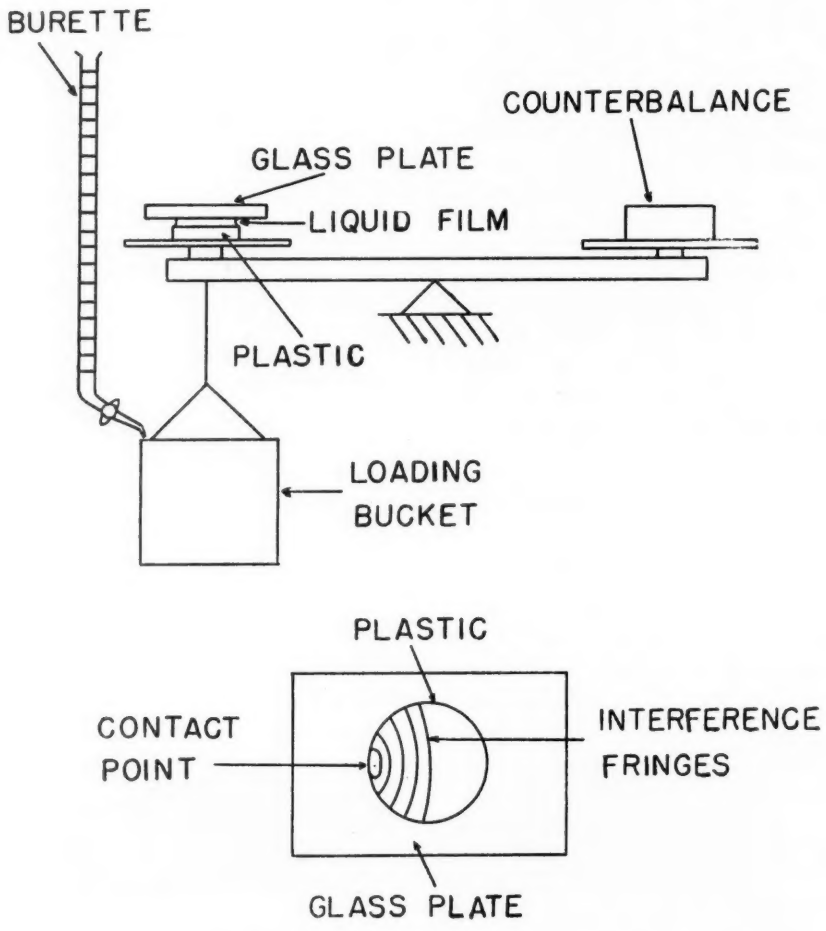



Fig. 4.—The equipment used for determining the retentive force values.

*Retentive Force Measurements.*—The plastic surface to be tested was placed on one of the pans of a trip balance, and a film was formed between the specimen and a glass plate above the pan (Fig. 4). The pans on a trip balance move in such a manner that the direction of movement approximates a straight line over small distances. Since the distance moved during rupture of the film is very small, the

trip balance was a satisfactory device for this purpose. The glass surface was used as a substitute for the oral tissues and is hard and unyielding in comparison to them. The retentive or separating force values obtained, therefore, were relative rather than absolute. Relative values, however, are adequate to check the effect of capillarity on retention.

The glass plate was aligned to parallel the flat surface of the specimen by mounting the plate on an adjustable tripod. The surfaces were roughly aligned by eye, with a liquid film formed between them. Final alignment was carried out by observing the interference fringe pattern. Adjustment of the tripod was conducted until a uniform pattern of interference fringes was obtained and the film drew back at a uniform rate from the edges of the specimen.

The retentive force was measured after the film had been formed, using a set load of 150 Gm. on the counterbalance pan. The excess liquid at the periphery was removed. Failure to remove the excess liquid resulted in low force values since the capillary forces were reduced. Water was added to the loading bucket from the burette until the surfaces separated. The weight of the water used to separate the surfaces revealed the retentive force. The rate of loading did not appreciably affect the retentive force. This would be expected for liquids having relatively low viscosities, such as saliva.

*Film Thickness Measurement.*—The film thickness of saliva was determined by measuring the retentive force using water and then methanol as the film. Since the surface tension, area, contact angle, and gravitational constant are known, the only unknown in the equation is the film thickness. The film thickness, therefore, was calculated and good agreement was obtained using water or alcohol. The thickness of the saliva film was assumed to be equal to the average of these values.

## RESULTS

The contact angles for distilled water and saliva on polymethyl methacrylate and polystyrene are listed in Table I. The measurements were made either on clean plastic surfaces or on those which had been stored in saliva. The samples stored in saliva were kept immersed for a minimum of 24 hours and then superficially rinsed with distilled water just prior to making the contact angle measurements. At least fifteen values for the advancing and receding angles were obtained for each condition.

The advancing contact angle values showed that the adhesion of water and saliva on clean polymethyl methacrylate and polystyrene was similar. The values also indicated improved adhesion of saliva to specimens stored in saliva. The receding contact angles for water on the plastic surfaces were 20 to 25 degrees less than the corresponding advancing angles. Of particular interest was the observation that the receding contact angles for saliva on the plastic surfaces were always zero. The receding angles, therefore, were 58 to 79 degrees less than the corresponding advancing angles. It is presumed that this decrease is due to an adsorbed film on the plastic surfaces.

The importance of the zero receding angles for saliva on plastics may be seen by referring to the equation. Since the cosine of the receding contact angle is in the numerator of this equation, the higher the value of the cosine, the higher the retentive force. When the receding contact angle is zero, the cosine of the angle attains the maximum possible value of 1. Any measurable contact angle results in a cosine value of less than 1 and would result in a reduction in the retentive force.

The surface tension of the saliva film is also present in the numerator of the equation, and, therefore, any increase in the surface tension will increase the retentive force. This is substantiated by the observation that patients with thick,

TABLE I. CONTACT ANGLES OF WATER AND SALIVA ON POLYMETHYL METHACRYLATE AND POLYSTYRENE AT 25° C.

| PLASTIC | LIQUID DROP | SURFACE TREATMENT | ADVANCING CONTACT ANGLE ($\theta_a$) | RECEDING CONTACT ANGLE ($\theta_r$) |
|---|---|---|---|---|
| Polymethyl methacrylate | Water | Clean | 76 ± 1 | 50 ± 1 |
| | Saliva | Clean | 75 ± 1 | 0 |
| | Saliva | Saliva | 68 ± 3 | 0 |
| Polystyrene | Water | Clean | 83 ± 1 | 64 ± 2 |
| | Saliva | Clean | 79 ± 1 | 0 |
| | Saliva | Saliva | 58 ± 5 | 0 |

ropy saliva of low surface tension have difficulty with denture retention. Patients having thin, watery saliva of higher surface tension do not have such difficulties. Östlund[3] measured the retentive force of denture bases with saliva samples having surface tension values from 52.8 to 62.8 dynes per centimeter. Forces of higher retention were obtained with the higher surface tension saliva samples.

The film thickness values obtained are reported in Table II. The saliva film thickness for the plastic surfaces and glass varied from 17 to 25 $\mu$. These values are in good agreement, considering the variations in alignment.

These various experimental data were substituted into the equation to obtain a calculated force of retention. These calculated values and the experimentally measured retentive force values are reported in Table II. The values of 140 and 148 Gm. for the experimental and calculated retentive force for the polymethyl methacrylate and saliva-glass system are in good agreement. Excellent agreement was also observed for the polystyrene and saliva-glass system. The retentive forces per unit area, at a constant film thickness, also are reported in Table II. The agreement of 43 and 45 Gm. force per square centimeter indicates no difference in retention between the polymethyl methacrylate and polystyrene denture-base plastics.

TABLE II. SALIVA FILM THICKNESS AND RETENTIVE FORCE MEASUREMENTS

| SOLID SURFACES | FILM THICKNESS ($\mu$) | CALCULATED RETENTIVE FORCE (GM.) | OBSERVED RETENTIVE FORCE (GM.) | FORCE/AREA AT 25 $\mu$ (GM./CM.$^2$) |
|---|---|---|---|---|
| Glass-glass | 17 | 162 | 176 | 50 ± 3 |
| Polymethyl methacrylate–glass | 22 | 148 | 140 | 43 ± 2 |
| Polystyrene-glass | 25 | 117 | 117 | 45 ± 1 |

The agreement of the experimental and calculated retentive force measurements shows that the force of capillary attraction is the principal physical factor involved in the retention of a denture base. The results also illustrate that the receding contact angle, surface tension of the film, area of the film, and thickness of the film affect the capillary force.

## DISCUSSION

Since a number of factors other than capillarity have been claimed to be responsible for the retention of dentures, a discussion of some of these factors should be considered.

The forces of adhesion have been used to explain retention. These forces, to be effective, must transfer their effect directly across the film of saliva. The following illustration shows how little the forces of adhesion affect retention directly. A value of 200 ounces may be taken as an average retentive force for a maxillary denture base. The effective area of the denture base may be 30 cm.$^2$, and the surface tension of saliva may be 54 dynes per centimeter. On the basis of these values, a film thickness of about 6 $\mu$ would be calculated from the previous equation. It has been proved that large molecules may be 0.006 $\mu$ long. The adhesive forces between the denture base and the oral tissues, therefore, would need to be transferred across a film at least 1,000 molecules thick. Since the forces between molecules are effective for only a few molecular layers, the forces of adhesion have no essential effect on retention.

Adhesion may effect retention indirectly, however. The adhesion of the saliva to the denture base may influence the receding contact angle. If the receding contact angle becomes measurable, the retention due to capillarity would be decreased.

Denture retention has been attributed to reduced pressure in the saliva film. This reduced pressure is a result of the curvature of the film at the meniscus. The reduction in pressure may be calculated by dividing twice the surface tension of the film by the radius of curvature. If the film thickness is about 10 $\mu$, the radius of curvature is approximately 5 $\mu$. Using this figure and 54 dynes per centimeter as the surface tension of saliva, the pressure reduction would be approximately 0.08

pounds per square inch (0.5 per cent of the atmospheric pressure). The reduced pressure in the saliva film, therefore, contributes little to the retention of a denture base.

Since the capillary force is affected by the surrounding pressure and temperature, substantially increasing or reducing these variables will influence the retention of a denture. The extent of the effect depends on the magnitude of the change. The capillary force is influenced also by the continuity of the saliva film, and any discontinuity will reduce the retentive force. Reduction of the outside pressure would contribute to film discontinuity.

The observation has been made that "drying" a patient's mouth by atropine sulfate injections increased denture retention.[6] The suggestion was made that the effect of capillarity on retention should be re-examined as a result of these data. It should be remembered that a film 25 $\mu$ thick and 5 cm.$^2$ in area requires only 0.01 ml. of liquid. As would be expected, after the rupture of the saliva film in the retention experiments, the plastic surfaces appeared completely dry. A more plausible explanation for the increased retention is that the film thickness was decreased, resulting in increased retention.

The previous discussion has dealt with retention of denture bases using saliva films. The equation presented is not applicable when denture powders are employed. The viscosity of the films formed is sufficiently high that this factor cannot be neglected. Equations have been developed for systems of this type where the viscosity or tackiness of the film and the duration of the force must be considered.[15] The force required to dislodge a denture that is retained by a film of denture powder and saliva is inversely proportional to the duration of the load. This means that higher forces of retention are observed for short rather than long applications of force. The dislodging force also is larger when the viscosity of the film is higher. Retentive force measurements obtained using denture powders, therefore, should include a study of the viscosity of the films and the rate of load application.

## SUMMARY AND CONCLUSIONS

The contribution of the forces of capillarity to denture retention was studied. The experimental retentive force measurements were made on a laboratory model composed of a plastic and a glass surface separated by a film of saliva.

The retentive force for this system also was calculated from an equation relating the retentive force to the surface tension of the saliva, the area of the film, the receding contact angle of saliva against plastic, and the saliva film thickness. These latter values were determined experimentally.

The retentive force values, calculated on the basis of capillarity, were in close agreement with experimentally determined retentive forces. These data indicate that capillary forces are the principal physical forces involved in denture retention.

## REFERENCES

1. Hardy, I. R., and Kapur, K. K.: Posterior Border Seal—Its Rationale and Importance, J. Pros. Den. **8**:386-397, 1958.

2. Snyder, F. C., Kimball, H. D., Bunch, W. B., and Beaton, J. H.: Effect of Reduced Atmospheric Pressure Upon Retention of Dentures, J.A.D.A. **32**:445-450, 1945.
3. Östlund, S. G.: Some Physical Principles in the Retention of Dentures, Northwest. Univ. Bull. **49**:11-20, 1948.
4. Skinner, E. W., and Chung, P.: The Effect of Surface Contact in the Retention of a Denture, J. Pros. Den. **1**:229-235, 1951.
5. Skinner, E. W., Campbell, R. L., and Chung, P.: A Clinical Study of the Forces Required to Dislodge Maxillary Denture Bases of Various Designs, J.A.D.A. **47**:671-680, 1953.
6. Campbell, R. L.: Some Clinical Observations Regarding the Role of the Fluid Film in the Retention of Dentures, J.A.D.A. **48**:58-63, 1954.
7. Campbell, R. L.: Effects of Water Sorption on Retention of Acrylic Resin Denture Bases, J.A.D.A. **52**:448-454, 1956.
8. DeVan, M. M.: Basic Principles in Impression Making, J. Pros. Den. **2**:26-35, 1952.
9. Moses, C. H.: Physical Considerations in Impression Making, J. Pros. Den. **3**:449-463, 1953.
10. Lammie, G. A.: The Retention of Complete Dentures, J.A.D.A. **55**:502-508, 1957.
11. Terrell, W. H.: Fundamentals Important to Good Complete Denture Construction, J. Pros. Den. **8**:740-752, 1958.
12. Cox, A. M.: A Consideration of the Fundamental Physical Principles Involved in the Retention of Artificial Dentures, Brit. D. J. **47**:1058-1070, 1926.
13. Stanitz, J. D.: An Analysis of the Part Played by the Fluid Film in Denture Retention, J.A.D.A. **37**:168-172, 1948.
14. du Noüy, L.: Surface Equilibria of Organic and Biological Colloids, New York, 1926, The Chemical Catalog Company, Inc.
15. Bikerman, J. J.: Surface Chemistry for Industrial Research, New York, 1948, Academic Press Inc., p. 359.

University of Michigan
School of Dentistry
Ann Arbor, Mich.

# THE ROLE OF LEARNING IN DENTURE RETENTION

N. Brill, L.D.S.,* G. Tryde, L.D.S.,** and S. Schübeler, L.D.S.**
*Royal Dental College, Copenhagen, Denmark*

Complete denture retention may be a challenge both to the dentist and his patient. The final outcome, be it success or failure, is decided by the responses of the dentist and his patient to the challenge. Responses of patients can be divided into three groups. To one group belong patients who can be treated with any denture (even the crudest) and will be satisfied. This group is no challenge to the dentist. To a second group belong those patients who can be treated with any denture (even one made by the most exacting technique) and never be satisfied. This group presents a real challenge. Between these two extremes is another group, which is by far the largest. The difficulties presented by the third group are usually overcome and will not be considered in this article.

When the first and second groups are compared, however, an intriguing problem concerning the correlation between denture retention and learning processes is revealed. Young people usually belong to the first group and are the "easy" patients. The second group is made up of older people; they are the "difficult" patients. Young people generally have a high capacity for learning, but this capacity gradually diminishes with increasing age and becomes extinct in old age. Progressive atrophy destroys functional elements of the cerebral cortex[1] and subcortical structures[2] which are involved in learning processes.[3] Signs of cerebral involution generally appear in people in their early forties.[4,1] Diseases, nutritional deficiencies, and stress cause an earlier precipitation of these signs.[2] Because the initial period of adaptation to complete dentures involves learning and some learning capacity, it follows that adaptation to complete dentures has neurological implications.

## LEARNING MECHANISMS

Unconditioned reflexes are innate and of ancient phylogenic origin, e.g., the sucking reflex as seen in the newborn child. They are absolute prerequisites for survival.[5] In order to live a normal life with appropriate muscle activity, however, man needs more than unconditioned reflexes. He must supplement these reflexes by establishing conditioned reflexes, and he must learn to modify muscle activity.

---

Some statements in this article do not reflect the teachings of the Prosthetic Department at the Royal Dental College, Copenhagen. Nevertheless, the rationale presented is substantiated by clinical and general observations.

*Associate Professor, Department of Prosthetic Dentistry.
**Instructor, Department of Prosthetic Dentistry.

An account of the formation of a conditioned reflex (Fig. 1) is given by Elliott[6]: "With a dog for subject, the ringing of a bell may originally set up impulses in a circuit that produces pricking of the ears. Some of the impulse will pass along collaterals to synapses with other circuits, but will not necessarily activate them, since the synapses may be too resistant. Now if food is given at the same time as the bell is rung, impulses will run along a path producing salivation and this will lower resistances in that path, so that impulses from the ear-pricking circuit can now jump intervening synapses. If this process is repeated frequently, the barrier between the two systems will, in some way, be permanently weakened. An arc of lower resistance will then be formed between the ear and the salivary

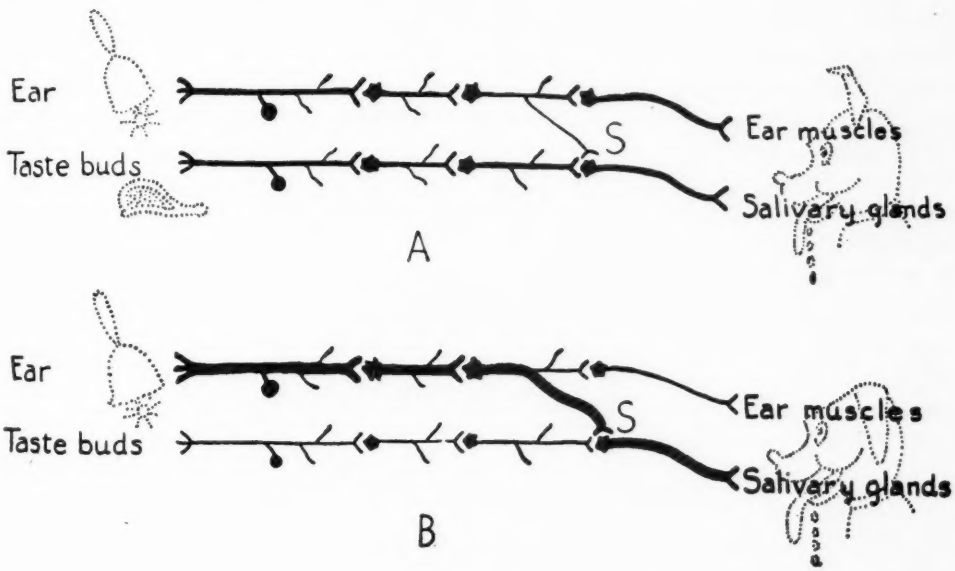



Fig. 1.—Supposed mechanism of the conditioned reflex. *A*, The path of least resistance is from ear to ear muscles; the synapse *(S)* is too resistant for ordinary impulse volleys to cross. If, however, the path from the taste buds to salivary glands is excited at about the same time, synaptic resistance at *S* is lowered and impulses can easily cross from the first chain. *B*, If this is repeated frequently, a path of low resistance will be established from ear to salivary glands. It must be emphasized that each "arc" is in reality a large web of neurons. Hence, breakthrough between two arcs is possibly a complex process. (From Elliott, H. C.: Textbook of the Nervous System, Philadelphia, 1954, J. B. Lippincott Co.)

glands, so that the ringing of a bell will cause salivation. And similarly a relationship can be set up between any stimulus and any response." The formation of such connections is a fundamental mechanism in the learning processes.

"This apparently simple device is, in fact, the most revolutionary development in the evolution of the brain."[6] This means that behavior, including muscle behavior, is no longer restricted to stereotyped responses performed by inflexible reflex arcs of ancestral heritage. On the contrary, it means that an individual can form new reflex arcs which are more suitable to the requirements of sensory input. He can learn by experience to respond in a purposeful manner to an almost infinite number of stimuli.[6,7] It should, however, be pointed out that although

the nervous connections are easily established in a young nervous system, one can hardly expect such connections to form other than with difficulty in an aging system, if they form at all.[8]

## DEMONSTRATION OF PURPOSEFUL MUSCLE BEHAVIOR

A report of a patient and how she mastered challenges set up by her upper denture will demonstrate the degree of perfection to which an acquired muscle behavior can develop.

The patient was a 63-year-old woman in good health. Temperamentally she was kind, a little shy, but otherwise well balanced. At the age of 25 (38 years previously), she had been fitted with a complete upper denture which she had worn since, day and night. She had been fully satisfied with this denture. A lower denture had never been made. In the years to follow, the number of lower teeth was gradually reduced by extractions.

Oral inspection revealed an edentulous upper jaw. The residual ridges were atrophied, but not severely. The mucosa of the ridges and hard palate was dense and bound firmly to the underlying bone. Its color was natural pink. No denture ulcers or hyperemic spots could be detected. The cuspids and first premolars remained in the lower jaw. These teeth were abraded slightly and discolored, and a few fillings were present in them. A slight inflammation of the marginal gingivae was observed. Mandibular muscles and joints appeared to be structurally and functionally normal. Apparently this patient, like the majority of persons in need of dental and prosthetic treatment, was just another ordinary patient; that this was not so was discovered when the denture was inspected (Fig. 2).

The denture was made of vulcanite rubber and poorly fabricated. No attempt to establish maximal extension of the denture base had been made. The flanges were short and thin. The teeth were arranged partly lateral to the ridges, and no signs of balanced occlusion were found. Because of the atrophy of the ridges which had occurred during the 38 years the denture had been in use, the denture base did not even approach fitting its foundation. As a consequence, the physical

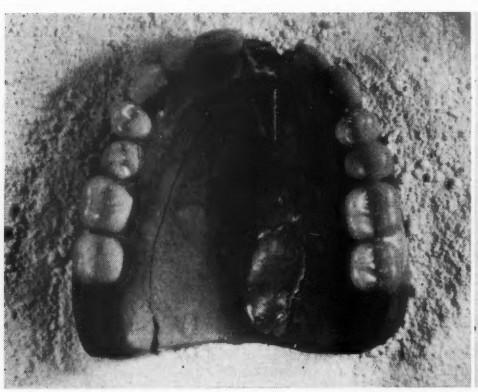


Fig. 2.

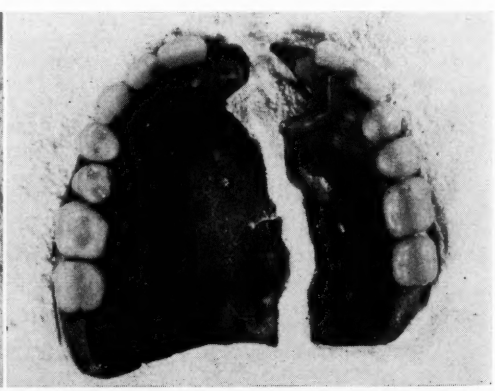


Fig. 3.

Fig. 2.—The denture had been worn for a total of 38 years.
Fig. 3.—The denture was worn for 5 years after it was fractured.

forces usually credited with retaining a denture were not operative. In spite of this, the denture had given trouble only on one occasion.

One day, 5 years previously, the denture fractured. It was repaired. A few days later it fractured again (Fig. 3). But since speaking, laughing, chewing, swallowing, etc., were not impaired and since the patient could even gnaw on bones with the fragments, she saw no reason for a second repair. Not until the left central incisor broke off did she want to have the denture repaired. She felt that the loss of this tooth spoiled her looks (Fig. 4).

The patient wanted only the missing tooth replaced, but after being told that a new complete upper and a removable partial lower denture were indicated, she accepted the diagnosis. Before treatment began, her ability to juggle with the broken denture was tested. During these experiments she never lost her grip on the denture. When she was requested to bite with different degrees of force on various instruments (cotton rolls, etc.) (Figs. 5 and 6), the denture fragments sometimes tilted on their foundation but remained against the upper jaw, partly because of the counterpressure from the instruments. Upon removal of the instruments, however, the fragments did not fall down as might have been expected. They were immediately and firmly reseated and kept in place by the tongue, upper

Fig. 4.—The patient's chief complaint was the unesthetic effect of the loss of the upper left central incisor.

lip, and cheeks. When gnawing on bone (Fig. 7), chewing cotton rolls, and smiling, the patient displayed the same expert performance. It did not matter whether the tests were carried out with both denture fragments simultaneously or with one or the other separately (Figs. 8, 9, and 10).

Fourteen days later, the right fragment and the part covering the hard palate of the denture fractured (Fig. 11). With the two pieces carrying teeth remaining, the tests were reapplied. No reduction in the capacity to stabilize the fragments was observed. The patient stated that eating, speaking, and other activities of the masticatory mechanism were performed as usual. She noted only that it was now easier to manipulate the left fragment than the right. Otherwise the situation was "normal."

The new upper denture had good retention. In about 2 weeks, she became fully accustomed to both new dentures. Four weeks later, she went through the same tests with the remnants of the old denture as had been made previously. This time she failed all of them. Her former skill in handling the fragments had been completely lost.

REFLECTIONS ON REFLEXES

Any person who needs and is capable of acquiring purposeful, coordinated muscle activity will develop it. This report is but one example of many. Being an extreme one, however, it demonstrates the importance of muscle activity in the retention of dentures. In the light of what is known about learning processes, some points will be elaborated.

Being young and at a formative age when she acquired her first denture, the patient had been able to adjust to its contingent inconveniences. Concomitant

Fig. 5.

Fig. 8.

Fig. 6.

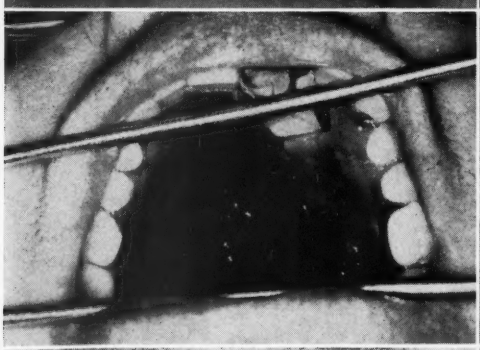


Fig. 9.

Fig. 7.

Fig. 10.

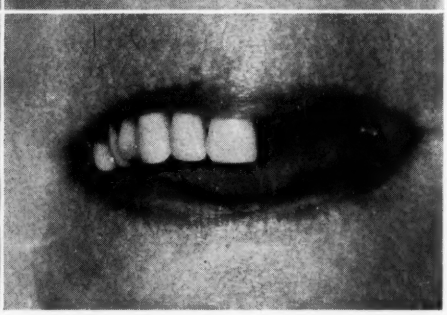


Fig. 5.—The fragments of the denture remained in position when the patient closed on the shaft of a mouth mirror.

Fig. 6.—The fragments remained in position during closure with wide jaw separation.

Fig. 7.—The patient could gnaw on bone with the old denture.

Fig. 8.—One fragment of the denture could be controlled during closure.

Fig. 9.—The contraction of the left buccinator muscle helped to hold the left fragment in place.

Fig. 10.—The left buccinator muscle contracted medially into the oral cavity with the right fragment in place.

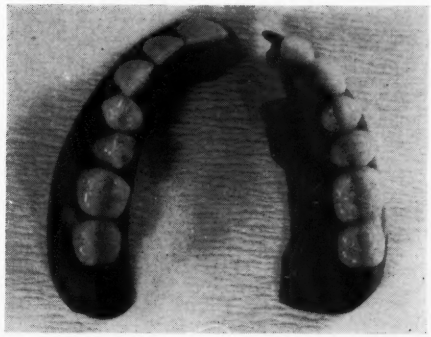


Fig. 11.—The patient could stabilize the two remaining fragments with the palatal portion missing.

with occasional extractions of lower teeth and progressive atrophy of the upper ridges, the denture lost retention and stability. Provoked by these handicaps, she gradually learned to utilize her muscles, especially those of the tongue, lips, and cheeks, so that she was able to stabilize the denture when smiling, speaking, chewing, and swallowing. New reflex patterns of her musculature were established. These patterns were so successful that they completely replaced the "classic" forces effective in denture retention, and she never found cause to complain.

When the denture fractured the first, second, and third times, she mastered the situation easily. However, we should not be misled into believing that she has retained her former capacity for learning to this day. The correlation between age and this capacity to learn suggests that her accomplishments in handling the denture fragments were like variations performed by a virtuoso who has been forced to practice for many years.

Another aspect of learning was illustrated also by this patient. The new upper denture did not require any muscle activity for its retention, and, therefore, her acquired reflex patterns were not called into action. They became disused, and in a matter of weeks the patient could no longer control the movements of the fragments. This was expected, because acquired patterns, like conditioned reflexes, are easily unlearned. The reason for this is suggested by the findings of Eccles and McIntyre.[9] They have shown that disuse of nervous pathways produces an increased synaptic resistance to impulse transmission in the pathways concerned, that is, muscular activity patterns may be forgotten transitorily or permanently. They can, however, be retained by constant repetition because, conversely, synaptic resistance decreases in a pathway which is used frequently.[9]

The important features put forward in this article are: (1) in advancing age, there is loss of functional elements in the central nervous system, (2) aging places limitations on the capacity of acquiring new muscle activity patterns, (3) adaptation in aged patients is achieved slowly, if it is achieved at all, and (4) young patients, who are not yet incapacitated, can readily learn to use even crude dentures skillfully. This report is a demonstration of potentialities in the young in this respect.

## REFLECTIONS ON CONSEQUENCES

Two conclusions concerning relevant therapy follow from these statements. The first is that complete dentures should be made preferably for young people, and, for such patients, it would be reasonable to make the dentures with a limited balanced occlusion which should be restricted to the muscular position of the mandible.[10,11] If a denture is devoid of balanced occlusion outside this position, it will be inconvenient for the patient to make lateral excursions because the occlusal forces applied will be concentrated at single points and pain may be produced. Moreover, the denture may slide or tilt and may even momentarily lose its retention. These effects will act as punishment and teach the patient to limit movement patterns of the mandible to pure "hinge" movements and, at the same time, reduce the forces applied. Thus, a decrease of horizontal forces may be expected. These forces are supposed to be more destructive to residual ridges than vertical forces. As yet, no scientific proof of this has been established. However, experienced prosthodontists know of innumerable older persons who were fitted with complete dentures while they were young and have not suffered a severe loss of their denture foundations. In contrast, older people often show rapid ridge resorption following denture insertion, and often their denture foundations are in poor shape because periodontal disease has destroyed the alveolar bone.

These observations lead to the second conclusion. By fluoridation projects, pedodontic treatment, extensive periodontal treatment, and various other dental health measures, modern dentistry combats caries and periodontal disease energetically. The eventual outcome of this fight is unknown. The results to date are inadequate in that these diseases and their sequelae have not been completely controlled.

In civilized countries, therefore, where life expectancy is increasing and where teeth are carefully preserved, the end result will be questionable in some instances. More and more patients will save teeth, and this will allow them to chew food adequately for several years. Thereby, these patients will advance into age groups where adaptation occurs only with difficulty. Some patients will be carried beyond the point where new muscle activity can be learned. Thus, in those people who ultimately must wear complete dentures and who are disabled because of bone destruction and atrophy of the central nervous system, dentistry has created a problem it cannot solve. This is a provocative statement, but the simple background to it is that the human masticatory mechanism is not built to stand the impact of civilization. Therefore, when therapy is formulated, the arguments presented must receive their proper consideration.

## SUMMARY

The clinical importance of learning and the capacity of learning relative to age are discussed and therapeutic aspects of wearing dentures are considered. Complete dentures are usually successful in young people, and, in such patients, dentures should be made with a balanced occlusion confined to a limited area in the muscular position of the mandible. Treatment with complete dentures in debilitated and cerebrally incapacitated older people is often irrelevant therapy.

REFERENCES

1. Kaes, T.: Die Grosshirnrinde des Menschen, Jena, 1907, Gustav Fischer, Part 2, pp. 11-13.
2. Anderson, W. A. D.: Pathology, St. Louis, 1953, The C. V. Mosby Co., pp. 64 and 1313-1320.
3. Gastaut, H.: Some Aspects of the Neurophysiological Basis of Conditioned Reflexes and Behaviour, *in* Wolstenholme, G. E. W., and O'Connor, C. M., editors: Symposium on the Neurological Basis of Behaviour, London, 1958, J. & A. Churchill, Ltd., pp. 255-272.
4. Heilbrunn, L. V.: An Outline of General Physiology, ed. 3, Philadelphia and London, 1952, W. B. Saunders Company, pp. 689 and 696-697.
5. Tilney, F., and Casamajor, L.: Myelinogeny as Applied to the Study of Behaviour, Arch. Neurol. & Psychiat. **12**:1-66, 1924.
6. Elliott, H. C.: Textbook of the Nervous System, ed. 2, Philadelphia, 1954, J. B. Lippincott Co., pp. 54-55.
7. Eccles, J. C.: The Neurophysiological Basis of Mind, Oxford, 1956, The Clarendon Press, pp. 193-227.
8. Apter, N. S.: Aging and Conditional Reflexes, *in* Gantt, W. H., editor: Physiological Bases of Psychiatry, Springfield, 1958, Charles C Thomas, Publisher, pp. 22-38.
9. Eccles, J. C., and McIntyre, A. K.: Plasticity of Mammalian Monosynaptic Reflexes, Nature **167**:466-468, 1951.
10. Osborne, J., and Lammie, G. A.: Partial Dentures, ed. 2, Oxford, 1959, Blackwell Scientific Publications, pp. 26-27.
11. Brill, N., Lammie, G. A., Osborne, J., and Perry, H. T.: Mandibular Positions and Mandibular Movements, Brit. D.J. **106**:391-400, 1959.

Royal Dental College
Universitetsparken 4
Copenhagen ø, Denmark

# TESTS OF BALANCED AND NONBALANCED OCCLUSIONS

VINCENT R. TRAPOZZANO, D.D.S.
*St. Petersburg, Fla.*

OCCLUSAL CONCEPTS fall into two general categories: (1) balanced occlusion and (2) nonbalanced occlusion. The question of which type of occlusion is physiologically acceptable is important from both a clinical and an economic standpoint. Procedures involved in producing a set of dentures with a "balanced" occlusion are much more complex and time consuming than those producing dentures with a "nonbalanced" occlusion. As dentists, it is reasonable to use technical procedures which produce acceptable clinical results in a minimum amount of time and effort.

## CONCEPTS OF OCCLUSION

The concept of balanced occlusion was well stated by Stansbery[1]: "Balanced occlusion involves a definite arrangement of tooth contacts in harmony with mandibular movement." To concur with this concept involves the acceptance of at least one basic underlying principle, namely, the presence of eccentric mandibular movement during function, particularly during masticatory function.

Occlusions built according to the spherical theory or on a flat plane may be classified as nonbalanced occlusions.

Jankelson and associates,[2] in a study of the physiology of the stomatognathic system by the use of cinefluorography, concluded: "The evidence strongly suggests that centric occlusion is the only tooth contact of any significance that occurs during stomatognathic function. Evidence of eccentric tooth balance during eating was not found. There was no evidence that balance of teeth in eccentric positions is a physiologic necessity, or that lack of eccentric balance is less conducive to masticatory function. The voluminous literature on occlusion furnishes little experimental evidence on this question."

Kurth[3] stated: "The prime requisite for a balanced occlusion in full denture construction is an accurate centric relation. I use a central bearing screw set to the correct vertical dimension, and moving upon a flat plate. A Gothic arch is traced, and its apex is checked with a plaster checkbite to determine eccentric relation. *I do not record any other eccentric positional relations* [italics mine], such as right or left lateral, because the patient does not normally use these relations in function, and if they were of value, the eccentric positions can be altered by checkbites

This study was made possible by a grant from the United States Veterans Administration. The entire investigation was conducted at the Bay Pines Veterans Administration Center, Bay Pines, Fla.

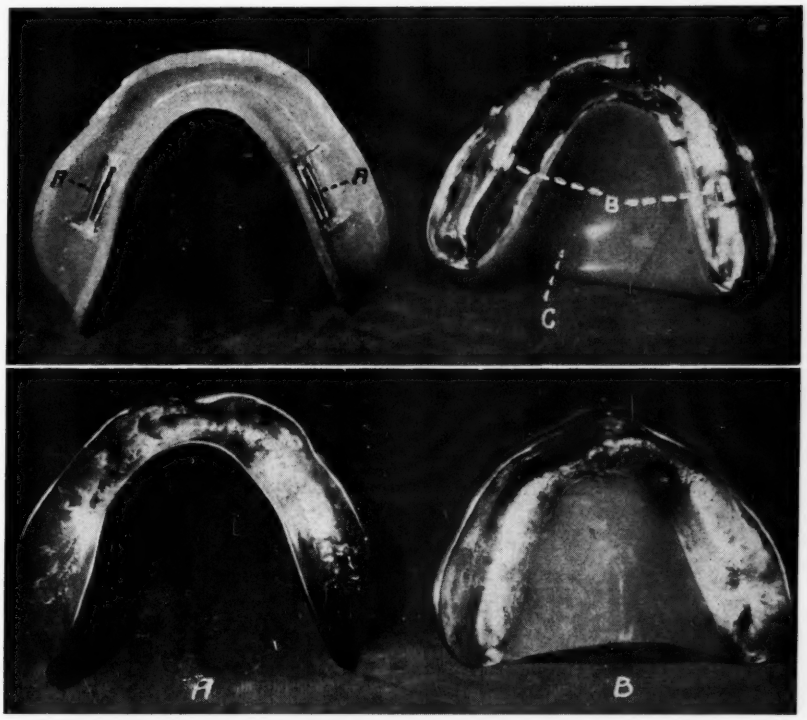



Fig. 1.—*A*, The tissue surface of the mandibular metal casting. *B*, The palatal surface of the maxillary denture base. *C*, The palatal portion is finished in acrylic resin.

obtained with a concave or convex plane." It should be noted that Kurth does not use the term "balanced occlusion" in the same sense as Stansbery.

The objective of this study was to compare patient reaction to and the relative efficiency of a balanced and a nonbalanced occlusion.

## METHODS AND MATERIALS

The changes in the occlusions were made on a common denture base. The use of a common denture base for the different types of occlusion allowed positive control of the occlusal factor being tested and permitted interchangeability of the occlusal schemes being tested. The comparative evaluation of different occlusal schemes was carried out in the patient's mouth under normal conditions of wearing dentures.

Because of the limited number of patients tested, this study was neither intended to nor does it give a complete answer to this question. The study does suggest a fundamental approach to further studies which may be used to guide us in our choice as to which type of occlusion is most acceptable.

## CONSTRUCTION OF THE TEST DENTURES

Without controlled studies, our concepts and techniques would be based on empirical evaluations. As in the previous investigations,[4,5] a common base was

used for each change of occlusion. In this manner the impression and its extension, adaptation, fullness, and retention would remain constant throughout the investigation. The construction of the common bases for the different occlusal schemes, the design of the insert attachment, and the technique for the construction of the attachment were the same as in the testing of the occlusal patterns[5] (Figs. 1 and 2).

In the construction of the dentures, the Hanau Model C face-bow was used to mount the maxillary cast on the Hanau SMX articulator. When making the nonbalanced type of occlusion, the articulator was locked so that only a hinge movement of the instrument was possible (Figs. 3 and 4). To set up the teeth in a balanced occlusion, it was necessary, in addition to the centric relation record, to record the protrusive relationship (Figs. 5 and 6). This record was transferred to the articulator in order to set the horizontal condylar guidances. The lateral condylar guides were set on the articulator by using the formula suggested by Hanau (H/8 + 12 = L). The balance of the technique used in the construction of the dentures was the same as that previously described.[5] Twenty-degree posterior teeth were used for both types of occlusion.

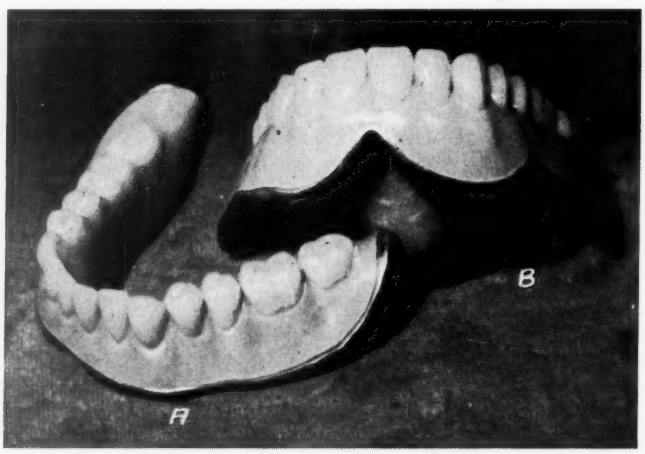



Fig. 2.—*A*, The mandiublar base with the insert in position. *B*, The maxillary base with the insert in position.

SELECTION OF PATIENTS

The patients were selected on the basis of their probable reliability to continue to the completion of the investigation, adequate interridge space, high intelligence, and experience wearing dentures. Selection was not made on the basis of the type or condition of the residual ridges—they varied from soft and flabby ridges to those which could be classified as normal (Table I). The patients were from 55 to 70 years of age. All had worn dentures with twenty-degree posterior teeth set in balanced occlusion. A lack of experience in wearing dentures was considered to be detrimental to the experiment, because patients with no denture-wearing experience would require varying lengths of time to learn the fundamentals of denture control.

By the time the patient had learned to control dentures, he could no longer be classified as inexperienced.

After the denture bases and inserts were completed, the dentures with the balanced occlusion were inserted first for patients 1 to 10, inclusively. The dentures with the nonbalanced occlusion were inserted first for patients 11 and 12. Which

Fig. 3. Fig. 4.

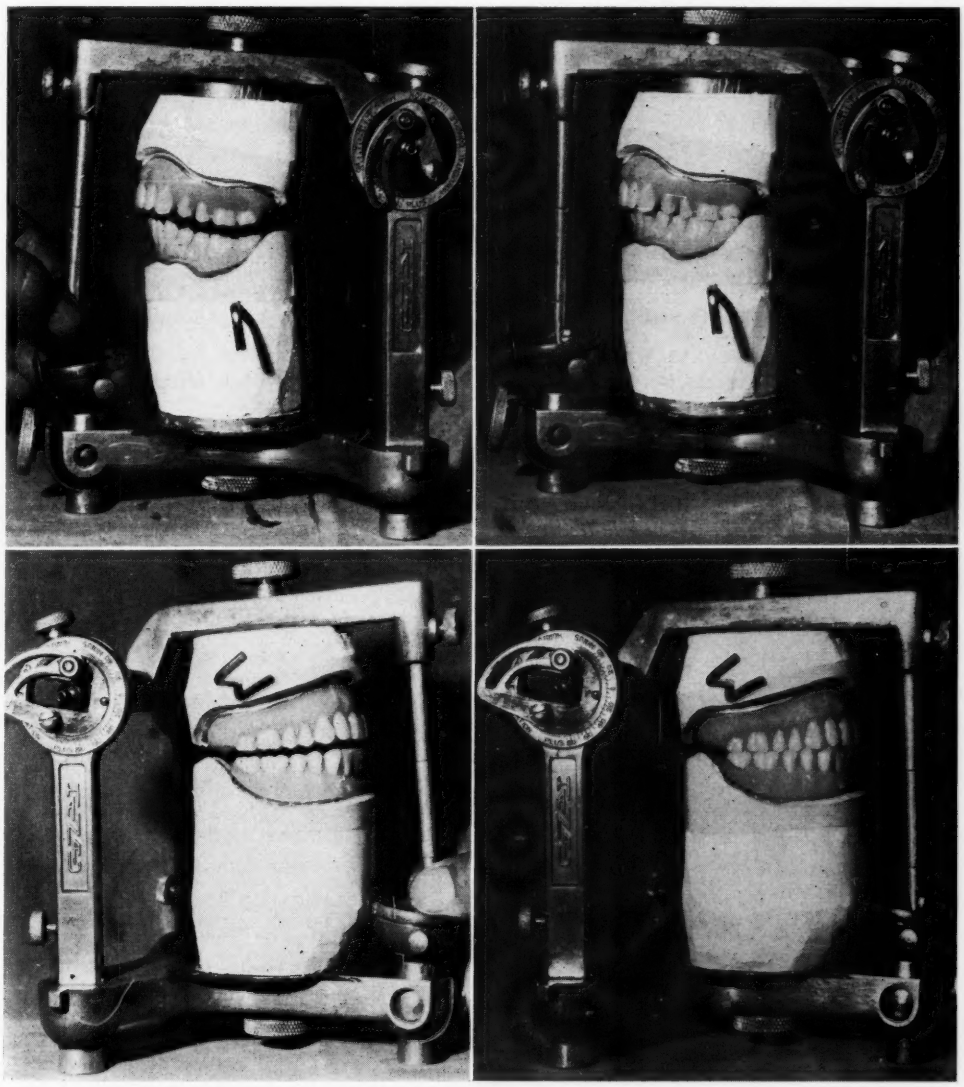


Fig. 5. Fig. 6.

Fig. 3.—Nonbalanced occlusion. The teeth are separated to show the erratic set up of the posterior teeth to ensure nonbalance.

Fig. 4.—Nonbalanced teeth in occlusion.

Fig. 5.—Balanced occlusion. The teeth are separated to show the cuspal angulation set in harmony with the controlling end factors.

Fig. 6.—Balanced teeth in occlusion.

occlusion (balanced or nonbalanced) the patient was permitted to wear first had no significance in the experiment. The cycle of changes in occlusion varied from 3 or 4 days to 3 and 4 weeks. The patients were permitted to wear the dentures for sufficient time to establish a pattern of reaction to either type of occlusion.

TABLE I. RIDGE CONDITIONS

| PATIENT | TYPE OF MAXILLARY RIDGE | TYPE OF MANDIBULAR RIDGE |
|---|---|---|
| 1 | Small with soft, flabby tissue from first premolar to first premolar | Small, V-shaped and spiny; the crest was covered by a band of soft, movable tissue |
| 2 | High V-shaped vault; the mucosa covering the bearing area was slightly movable | Thin, high, sharp, and spiny |
| 3 | Well formed with only slightly movable soft tissues covering | Well formed with only slightly movable soft tissue covering |
| 4 | Small with loose, flabby tissue from first premolar to first premolar | V-shaped with a lingual inclination; soft tissue quite movable |
| 5 | Well formed with mucosal covering of normal thickness | Well formed with mucosal covering of normal thickness |
| 6 | Small with mucosal covering of normal thickness | Small and flat with easily movable tissues on the ridge crest |
| 7 | Well formed with slightly movable mucosal covering from cuspid to cuspid | High and spiny; crest covered with soft, easily displaceable tissue |
| 8 | Average height; covered with hard and unyielding soft tissue | High with severe undercuts on the buccal, labial, and lingual surfaces |
| 9 | Average size with soft and flabby mucosal covering from first premolar to first premolar | Average size with quite movable tissue from cuspid to cuspid and prominent tori on right and left sides in premolar areas |
| 10 | Small arch with narrow ridge with parallel sides | Quite small with a high V-shaped crest |
| 11 | Small with soft and easily displaced mucosal covering from cuspid to cuspid | High and narrow with easily displaced mucosal covering |
| 12 | Average size and well formed with soft mucosal covering from cuspid to cuspid | Average size arch with high and narrow ridge; the mucosal covering was soft and movable |

## PATIENT REACTION AND COMMENTS

Patient reaction and comments must receive careful evaluation. Frequently, a patient will react to the spirit of the investigation and the personality of the investigator. It was made clear to the patient that his reactions and reports would be acceptable and that the investigator had no personal interest in what was reported. The reminder was repeated from time to time since it was found that the patient would, on occasion, try to answer questions in a manner which *he thought would please the investigator*. Frequently, subjective responses were at odds with objective findings. Insofar as was possible, subjective responses were supported by objective symptoms (Table II).

### PREFERENCE OF PATIENTS

Seven patients indicated no preference for either the balanced or the nonbalanced occlusion, while 3 preferred the nonbalanced occlusion and 2 the balanced occlusion. The preference for the balanced occlusion by 1 patient was somewhat doubtful (Table II).

### CHEWING TESTS

Comparative chewing tests[5] of occlusal efficiency were made with carrots and freshly roasted peanuts as the test foods. These foods were selected because they do not readily disintegrate into fine particles during mastication. It was necessary to rely upon the patients' subjective responses to determine the chewing efficiency as it applied to the total diet. This latter procedure may be open to question.

The carrots were cut into approximately ⅜-inch squares. No attempt was made to dictate to the patients the number of squares which they were to attempt to chew on each trial. It was suggested that they should chew on one or both sides, or in any manner which seemed most comfortable to them. The number of masticatory strokes which the patients were to be permitted was first determined by having them chew several test boluses of food. The number of strokes made up to the time of deglutition of the food was counted and averaged. This average was noted for each patient and that was the number of strokes permitted. It was found that approximately the same number of strokes was used whether the patient was chewing peanuts or carrots.

A 100-mesh screen was used as a sieve to study the size of the remaining particles and weight changes in the test materials after mastication by the patient (Table III).

### FINENESS OF CHEW

A number of observers not connected with the investigation were asked to evaluate the relative fineness of the residual chew of both the peanuts and the carrots. The results of these observations are tabulated in Table IV.

An analysis of the relationship of the mouth conditions with the chewing tests and the patients' choice of occlusion was made (Tables III and IV). Four patients had mouth conditions which could be classified as "favorable," while 8 had ridge types and forms which could be classified as "unfavorable."

Of the 4 patients (3, 5, 6, 12) with favorable ridge type and form, 3 (3, 5, 6) expressed no particular choice between the balanced and nonbalanced occlusions, despite the greater efficiency of the balanced occlusion. One patient (12) preferred the nonbalanced occlusion and could chew more efficiently with it.

Of the 8 patients (1, 2, 4, 7 to 11) with unfavorable ridge type and form, 4 (1, 2, 4, 8) had no particular preference for either balanced or nonbalanced occlusion, despite the fact that the balanced occlusion was more efficient. Two patients (7, 11) preferred the nonbalanced occlusion. Chewing efficiency for patient 7 was better with the nonbalanced occlusion, while for patient 11 the balanced occlusion was more efficient.

TABLE II

| PATIENT | PATIENTS' COMMENTS | | OBJECTIVE OBSERVATIONS |
|---|---|---|---|
| | BALANCED OCCLUSION | NONBALANCED OCCLUSION | |
| 1 | "These hold a little tighter. Can eat much better with these" | "Eating is normal, except with too large a mouthful. Teeth seem looser." On last day, "Chewing is good. Can eat anything. Can use these as well as the others" | No untoward irritation with either; patient had no preference for either type after gaining experience with them |
| 2 | "Getting along well" | "Getting along well" | Ridge soreness developed because of faulty bases, and new dentures were made |
| | "Can eat anything. Different than the others [nonbalanced] but not objectionable" | "Chewing everything they give me. These seem to be better than the others." Later, "Not much difference between these and the others" | The new bases relieved the soreness; the patient had no preference for one type of occlusion over the other |
| 3 | "Not a bit of trouble." Ate meat and chewed well | "Not a bit of trouble." Ate meat and chewed well | No notable irritation from either occlusion; patient had no preference for either |
| 4 | "Very good chewing. Better than my own natural teeth. Very good" | "Very good chewing. Better than my own natural teeth. Very good" | No notable irritation by either occlusion; no particular preference for either occlusion |
| 5 | "Teeth seem to be fine and chewing good. No difference between these and the others" | "Teeth seem to be fine and chewing good. No difference between these and the others" | Slight soreness developed on the buccal and lingual borders in the incisor region with both types of occlusion; the base was relieved and the patient had no preference for either occlusion |
| 6 | "Chew anything. Getting along very well. No difference between these and the others" | "It was a pleasure to eat food. I can chew on both sides" | Slight irritation on the lingual side of the mandibular ridge and the right buccal region with either type of occlusion; when relieved of soreness, patient had no preference |
| 7 | "Chewing good. More comfortable than since we started. No pain. No discomfort. Getting along better than last week [with nonbalanced occlusion]" | In first part of test, "Chewing good. These teeth are slightly looser than the others." At the end of the test, "Getting along good. No trouble with chewing" | Soreness in the right mandibular region and anterior ridge crest developed early in test as result of error in centric occlusion; after correction, patient preferred nonbalanced occlusion |
| 8 | "See no difference" | "See no difference" | No appreciable soreness with either occlusion; patient had no preference |

TABLE II—(CONT'D)

| PATIENT | PATIENTS' COMMENTS | | OBJECTIVE OBSERVATIONS |
|---|---|---|---|
| | BALANCED OCCLUSION | NONBALANCED OCCLUSION | |
| 9 | "Getting along fine and can chew well. They stay in place" | "Can't chew as well, but fit fine. No trouble holding them in." At end, "These are all right, but the others stay in better" | No appreciable soreness with either occlusion; patient preferred balanced occlusion |
| 10 | "Getting along very well. No complaint. Satisfied" | "Gag a little, but they stay in place as well as the others" | No notable irritation by either occlusion; patients had slight preference for balanced occlusion |
| 11 | "Teeth are dull, very blunt" | "Fit the mouth much better" | Slight soreness on the lingual side of mandibular ridge from cuspid to cuspid; patient preferred nonbalanced occlusion |
| 12 | | "Feel good. Chew very well. Feel more like teeth should be" | About half way through the test period, an error in centric occlusion was discovered and corrected; patient still preferred nonbalanced occlusion |

Two patients (9, 10) had only a slight preference for the balanced occlusion. While patient 10 had a slight preference for the balanced occlusion, he had greater chewing efficiency with the nonbalanced occlusion.

In Table IV, it will be noted that 1 patient (1) had a greater fineness of chew of carrots with the nonbalanced occlusion. For 2 patients (9, 10), the fineness of the chew was considered to be the same for the balanced and nonbalanced occlusions.

Less clear-cut lines were evident when the fineness of chew of peanuts was judged. Five patients (3 to 6, 11) had a greater fineness of chew with the balanced occlusion. Four patients (1, 7, 8, 12) had a greater fineness of chew with the nonbalanced occlusion. Three (2, 9, 10) achieved the same fineness of chew with both types of occlusion.

### TRACINGS OF CHEWING CYCLES

Tracings of the patients chewing peanuts and carrots were made in the frontal plane. To make these tracings, the stylus was attached to the mandibular dentures in such a manner as to cause the least amount of interference with the chewing. The patients were permitted to place as much of the test food in the mouth as they thought they could chew comfortably. Figs. 7 to 9 show the tracings of the chewing cycles of 3 patients (1, 9, 12). It will be noted that while masticating with the balanced occlusion, the stroke was slightly wider near the finish of the

TABLE III. COMPARISON OF OCCLUSAL EFFICIENCY

| PATIENT | TYPE OF OCCLUSION | WEIGHT OF PEANUTS CHEWED (GM.) | WEIGHT OF PEANUTS RECOVERED (GM.) | WEIGHT OF PEANUTS PASSING THROUGH 100-MESH SIEVE (GM.) | PERCENTAGE PASSING THROUGH SIEVE | MOUTH CONDITION OF PATIENT | PATIENT PREFERENCE FOR BALANCED OR NONBALANCED OCCLUSION |
|---|---|---|---|---|---|---|---|
| 1 | Balanced | 5 | 0.54 | 4.46 | 89.2 | Not favorable | Either |
| | Nonbalanced | 5 | 0.78 | 4.22 | 84.4 | | |
| 2 | Balanced | 5 | 1.32 | 3.68 | 73.6 | Not favorable | Either |
| | Nonbalanced | 5 | 1.55 | 3.45 | 69.0 | | |
| 3 | Balanced | 5.84 | 1.36 | 4.48 | 76.7 | Favorable | Either |
| | Nonbalanced | 5.84 | 1.64 | 4.20 | 71.9 | | |
| 4 | Balanced | 5 | 1.38 | 3.62 | 72.4 | Not favorable | Either |
| | Nonbalanced | 5 | 1.53 | 3.47 | 69.4 | | |
| 5 | Balanced | 5 | 0.70 | 4.30 | 86.0 | Favorable | Either |
| | Nonbalanced | 5 | 1.60 | 3.40 | 68.0 | | |
| 6 | Balanced | 5 | 0.64 | 4.36 | 87.2 | Favorable | Either |
| | Nonbalanced | 5 | 0.73 | 4.27 | 84.4 | | |
| 7 | Balanced | 5 | 0.77 | 4.23 | 84.6 | Not favorable | Nonbalanced |
| | Nonbalanced | 5 | 0.48 | 4.52 | 90.4 | | |
| 8 | Balanced | 5 | 1.11 | 3.89 | 77.8 | Not favorable | Either |
| | Nonbalanced | 5 | 1.36 | 3.64 | 72.8 | | |
| 9 | Balanced | 5 | 0.74 | 4.26 | 85.2 | Not favorable | Balanced |
| | Nonbalanced | 5 | 0.87 | 4.13 | 82.6 | | |
| 10 | Balanced | 4.11 | 1.16 | 2.95 | 71.7 | Not favorable | Balanced |
| | Nonbalanced | 4.11 | 1.10 | 3.01 | 74.2 | | |
| 11 | Balanced | 5 | 2.00 | 3.00 | 60.0 | Not favorable | Nonbalanced |
| | Nonbalanced | 5 | 2.77 | 2.23 | 44.6 | | |
| 12 | Balanced | 5 | 1.41 | 3.59 | 72.5 | Favorable | Nonbalanced |
| | Nonbalanced | 5 | 1.30 | 3.70 | 74.0 | | |

chewing cycle than when the nonbalanced occlusion was being used. This would indicate that where some freedom of lateral movement was provided for in the occlusion, the patient would employ lateral movement.

## SUMMARY

1. Test denture bases with interchangeable inserts with "balanced" and "nonbalanced" types of occlusion were made for 12 patients. Both types of occlusion were constructed to the *same* centric relation record. Subjective observations of the 12 patients were recorded along with objective observations of chewing efficiency tests and a correlation with the ridge conditions.

2. The subjective responses indicated that 7 had no preference for either the balanced or the nonbalanced occlusion. Three preferred the dentures with the non-

balanced occlusion. Two preferred the balanced occlusion (one of these stated his preference for the balanced occlusion with reservation).

3. Neither type of occlusion produced soreness which could be attributed directly to the type of occlusion being used.

4. There was slightly more complaint about the relative "looseness" of the dentures with the nonbalanced occlusion than there was with the balanced occlusion.

5. For 9 patients, there was greater efficiency of chewing with the balanced occlusion. In 3, the chewing efficiency was greater with the nonbalanced occlusion. The balanced occlusion showed a greater efficiency based on fineness of chew when carrots were being chewed. When peanuts were chewed, the difference in efficiency between the balanced and nonbalanced occlusions was not so clearly defined. This indicates that the chewing efficiency of both forms of occlusion varies with the types of food.

The balanced occlusion showed a greater chewing efficiency for 9 patients, but the degree of difference was decisive only in 2 of them (5, 14 per cent; 11, 15.4 per cent). In the other 7, the percentage of difference was between 2.5 and 5.0. This slight difference could be attributed to experimental error and can be considered valid only because of the *relatively* large number of subjects in which it occurred.

In the 3 patients whose nonbalanced occlusions showed greater chewing efficiency, the difference was also slight (from 1.5 to 5.8 per cent).

TABLE IV. FINENESS OF CHEW

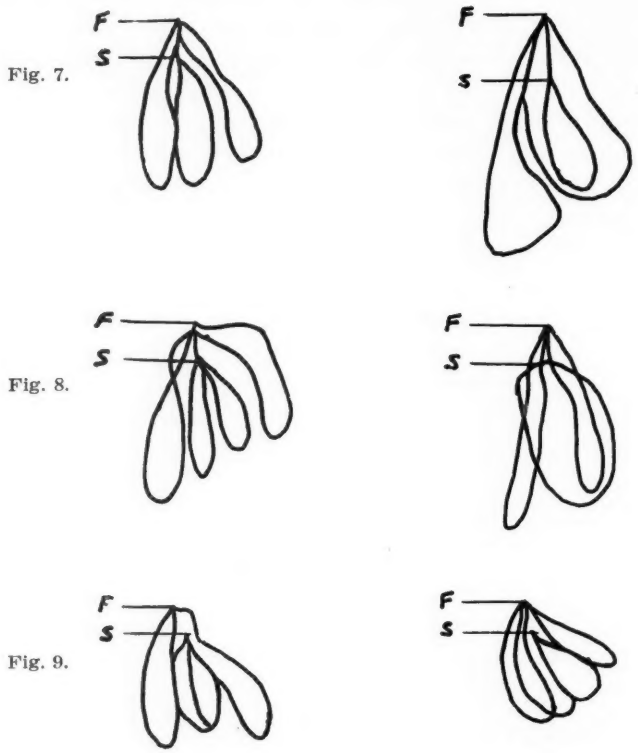
| PATIENT | NUMBER OF OBSERVERS | BALANCED OCCLUSION | NONBALANCED OCCLUSION | SAME FINENESS |
|---|---|---|---|---|
| *Peanuts* | | | | |
| 1 | 5 | | 5 | |
| 2 | 5 | | | 5 |
| 3 | 6 | 4 | 2 | |
| 4 | 5 | 5 | | |
| 5 | 5 | 5 | | |
| 6 | 5 | 4 | 1 | |
| 7 | 5 | | 5 | |
| 8 | 5 | | 5 | |
| 9 | 5 | | | 5 |
| 10 | 3 | 1 | 1 | 1 |
| 11 | 5 | 5 | | |
| 12 | 5 | | 5 | |
| *Carrots* | | | | |
| 1 | 5 | | 5 | |
| 2 | 5 | 5 | | |
| 3 | 6 | 6 | | |
| 4 | 5 | 5 | | |
| 5 | 5 | 5 | | |
| 6 | 5 | 5 | | |
| 7 | 5 | 4 | 1 | |
| 8 | 5 | 5 | | |
| 9 | 5 | | | 5 |
| 10 | 3 | | | 3 |
| 11 | 5 | 5 | | |
| 12 | 5 | 5 | | |

CONCLUSIONS

1. Patient preference or lack of preference is not a reliable yardstick in the evaluation of occlusion; however, the factor of preference cannot be totally ignored.

2. Among 12 patients studied, 2 preferred a balanced occlusion, 3 preferred nonbalanced occlusion, and 7 had no preference.

3. Tracings made in the frontal plane indicate that patients will make eccentric movements during mastication in varying degrees if the occlusion permits this movement.




**Figs. 7 to 9.—Frontal plane tracings indicating start of chewing cycle *(S)* and finish of chewing cycle *(F)*. *A*, Balanced occlusion. *B*, Nonbalanced occlusion. Fig. 7 shows tracings from patient 1; Fig. 8, patient 9; Fig. 9, patient 12.**

4. Ten patients in this investigation *adapted* their mandibular movements to the lack of provision for free movements in eccentric positions during function.

5. Nine patients chewed with greater efficiency with a balanced occlusion than with a nonbalanced occlusion. The difference was decisive in 2 patients. When the entire diet and the patients' subjective reactions were considered, neither type of occlusion was considered to have greater over-all efficiency.

6. Neither type of occlusion produced a greater degree of soreness than the other. Neither type tested in this investigation demonstrated a marked superiority over the other.

7. There are some patients who do use eccentric movements during mastication, but this study indicates the percentage who need them is small. A simple test of masticatory function should be devised which will indicate, before the construction of dentures is started, whether or not patients need provision for bilateral balance.

REFERENCES

1. Stansbery, C. J.: Balanced Occlusion in Relation to Lost Vertical Dimension, J.A.D.A. **25**:229, 1938.
2. Jankelson, B., Hoffman, G. M., and Hendron, J. A., Jr.: The Physiology of the Stomatognathic System, J.A.D.A. **46**:375-386, 1953.
3. Kurth, L. E.: Balanced Occlusion, J. Pros. Den. **4**:150-167, 1954.
4. Trapozzano, V. R., and Lazzari, J. B.: An Experimental Study of the Testing of Occlusal Patterns on the Same Denture Bases, J. Pros. Den. **2**:440-457, 1952.
5. Trapozzano, V. R.: Testing of Occlusal Patterns on the Same Denture Base, J. Pros. Den. **9**:53-69, 1959.

3900 Central Ave.
St. Petersburg 11, Fla.

## DISCUSSION OF "TESTS OF BALANCED AND NONBALANCED OCCLUSIONS"*

S. HOWARD PAYNE, D.D.S.
*University of Buffalo, School of Dentistry, Buffalo, N. Y.*

NO ONE WHO KNOWS DR. TRAPOZZANO can doubt his scientific approach or question the accuracy of this investigation. It is certainly valid. On the other hand, knowing him as I do, I can almost hear him say as he wrote the final phrases of his article, "There you guys, let's see you kick that around awhile!"

If Dr. Stansbery were here, he probably would now rise and make the point that occlusion cannot be accurately balanced on an articulator that will not accept all lateral occlusal records. In this study, I do not believe this criticism would be valid in view of the short wearing period and the fact that mastication was the significant part of the testing, rather than rubbing contacts.

In any study of this sort, the investigator cannot help but be impressed by the variables which creep in. As Trapozzano pointed out, the *subjective responses* often differed from the *objective findings.* There is danger that the student or young dentist might be tempted, on the basis of this investigation, to feel that "anything goes"; that only "fanatics" balance occlusion. Let me make the statement here and now that since I have been using a three-dimensional instrument set to lateral occlusal records and freeing the occlusion with a rotary grinder, my own post-insertion adjustments have been reduced by one-half.

There are certain observations which can be made that have a bearing on the problem.

Balanced occlusion is not needed for chewing. We have all seen an "old" upper denture used with a "new" lower denture, or vice versa, with great success as far as the patient was concerned. I cannot accept the statement that "balanced occlusion presupposes that the patient utilizes eccentric movements during function." Trapozzano has shown this, and there is ample evidence of it from other investigations. The *shape* of the chewing cycle as recorded in the frontal plane will vary according to the size, texture, and resistance of the food bolus and *can* vary with the resiliency of the tissues, the joint, and the tilting tendencies of the dentures.

Arranging the teeth on the articulator in harmonious eccentric occlusions has little to do with *normal* chewing. In many patients, however, this harmonious arrangement spells the difference between comfort or soreness, between success or failure. Harmonious occlusion will minimize tipping and give a greater degree of

Read before the Academy of Denture Prosthetics, Louisville, Ky.
*Trapozzano, Vincent R.: J. PROS. DEN. 10:476-487, 1960.

horizontal stability should the patient close the teeth together in eccentric positions when no food is interposed. A premature posterior contact can cause bruxism with dentures just as it can with natural occlusions.

Therefore, as Trapozzano suggests, our task is to learn how to determine the amount of mandibular excursion the patient *might* use. The case history, the physiologic condition, the memory patterns of the muscles, and the length of time the jaws have been edentulous must be considered.

An individual who possesses natural teeth with very high cusps which lock in centric occlusion does not have the habit of bruxism; neither is the prognathic person likely to use eccentric glides. Do these people need eccentric occlusal balance? Probably not.

A patient with an orthognathic relation or one who has had posterior teeth missing on one side for many years will tend to use a greater eccentric range of movement.

If the occlusion on the new dentures harmonizes with the memory pattern, necessitating a minimum accommodation by the organism (the patient), the dentures seem to him to be "just like my own" or "better than my own."

*It is always quite obvious that the innate adaptability and neuromuscular coordination of the patient are factors of extreme significance.*

Age, health, and sex are most important in gauging the adaptability of the individual patient. No further comment is needed except to emphasize the fact that menopausal and postmenopausal women of stress type (either very slim or very obese) are a real challenge. About 80 per cent of the problem patients fall into this category.

The patient is aware of the "feel" of the teeth and the amount of occlusal friction present. I well remember Dr. Felix French citing the experience of one of his patients whom he sent home with new dentures. The patient returned in 48 hours and was very happy with the ability he had to chew lettuce with the new teeth. French milled the teeth at that sitting, and the patient subsequently reported that they were not nearly as efficient.

Porcelain glazed to porcelain or porcelain glazed to resin provides minimum friction in gliding or bruxism. Grinding or milling produces a rougher surface as well as a more intimate occlusion. An occlusion which is too intimate does not seem efficient to the patient. Point contacts make for a *feeling* of accomplishment. *We all like to feel teeth go through food.* There is a psychologic satisfaction to it. If our teeth are too flat, our occlusal contacts too broad, or if insufficient escapeways are present, we feel as if we only squeeze the bolus of food.

On the basis of this investigation and others, we have found that the patient's estimation of his own chewing efficiency is not always valid. Patients are individuals. Most of them can and will adapt to complete dentures on the basis of satisfaction with appearance and confidence in their dentist. Certainly, *accuracy* will not hinder their adaptation.

University of Buffalo
School of Dentistry
Buffalo 14, N. Y.

# TROUBLE SHOOTING IN COMPLETE DENTURE PROSTHESIS
## Part IV. Proper Adjustment Procedures*

JOSEPH S. LANDA, D.D.S.
*New York, N. Y.*

PROPER ADJUSTMENT OF NEW DENTURES for relief from pain can follow only correct diagnosis. We must have answers to the following questions: (1) Is the pain limited to a certain spot or is it diffuse? (2) Is the painful spot clearly discernible through manifestation of the pathologic characteristics (vascularization, irritation, or ulceration)? (3) Is the patient specific as to the location of the soreness or does he complain of a vague pain throughout the entire left or right side? (4) Does the patient's complaint vaguely involve the entire oral cavity, and, if so, does he describe the pain as acute and severe or just dull and depressing?

The dentist must assume that 99 out of 100 patients' claims of pain are factual, though an examination may not disclose the expected symptoms. Knife-edge mylohyoid ridges, the sharp lingual edges of the flat bony platforms that run from the genial tubercles to the cuspids, and the sharp bony projections on the labial surface of the lower and upper ridges are frequently sources of soreness. Yet these painful areas cannot, at times, be detected by visual examination alone but must be detected by a digital exploration of the involved tissues as described previously.[1]

### TREATING TRAUMATIC OCCLUSION

A diffuse inflammatory condition over an extended area of the lower ridge is caused frequently by premature contact of the posterior teeth on the affected side. This inflammation is characterized by redness, with dispersed small granulations over the entire area. It may also result from an infection caused by unsanitary dentures. Obviously, this latter condition will not be cured by shaving or grinding the denture base. The cause of the particular soreness must be removed. First, I paint the inflamed tissue with tincture of Merthiolate 1:1,000. Then the patient lifts the tip of the tongue to the junction of the hard and soft palates and brings the teeth together gently. I observe carefully whether or not the teeth effect contact and then ask the patient whether he feels the teeth hit first on that side. If I observe deflective occlusal contacts and the patient substantiates it on his own accord, the dentures are remounted on the articulator. Small errors in occlusion are corrected

*Part I, J. PROS. DEN. 9:978-987, 1959; Part II, J. PROS. DEN. 10:42-46, 1960; Part III, J. PROS. DEN. 10:263-268, 1960.

with stones, but pronounced errors are corrected by resetting the teeth in balanced occlusion. The purpose in either instance is to re-establish the balanced occlusion of the dentures.

### MANDIBULAR LESIONS

The lesion of the masticatory mucosa on the lower ridge may be small and circumscribed, with a minute ulceration in the center. This lesion may be caused by displacement of the tissue by the impression, by injury to the cast, or by premature contact of one high cusp. The cause must be established carefully for the treatment to be effective. If the denture base is at fault, the tissue surface of the

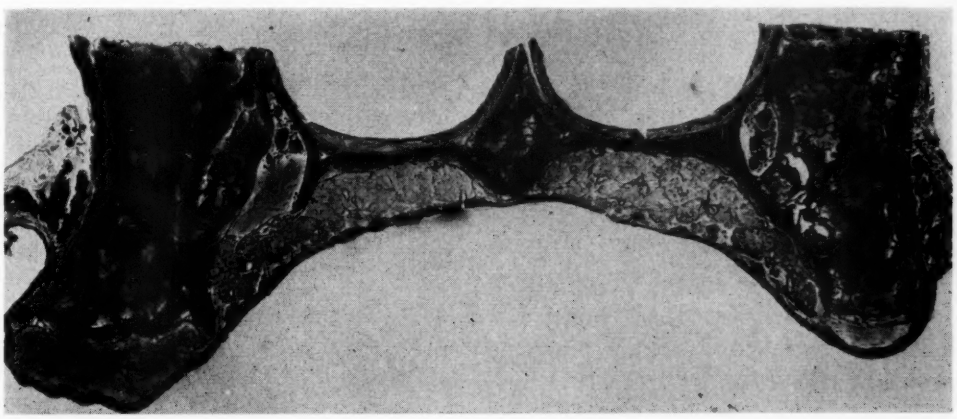


Fig. 1.—The mucosa covering the torus palatinus is very thin and will require adequate relief to permit uniform settling of the upper denture. (From Pendleton, E. C.: Changes in the Denture Supporting Tissues, J.A.D.A. 42:1-15, 1951.)

denture that corresponds to the ulceration is located with indelible pencil and reduced. If a high cusp is responsible for the ulceration, the dentures are remounted on an articulator and the high cusp reduced.

Longitudinal lesions which measure about 1.5 cm. in length and 5 to 6 mm. in width also occur on the lingual slope of the lower ridge. The surface texture is rough, and a thin, white surface membrane is about to exfoliate from the ulcerated area. The tissue under the membrane is raw, red, and inflamed. The lesion is located by means of an indelible pencil and the denture base is reduced about 0.5 mm. in depth with a round bur. The patient is instructed not to wear the dentures for 24 hours, to use a mild alkaline mouthwash, and to return for observation 48 hours after the denture has been worn.

This type of lesion is most frequently found with dentures defective in stability because the constant friction is injurious to the mucosa. However, it may be a local manifestation of a general condition, such as anemia, diabetes, or syphilis, or may result from a sharp mylohyoid ridge. Pain is to be expected from friction of the rigid denture against this sharp ridge unless preventive measures are instituted

during the construction of the dentures. Relief of these sharp ridges may be achieved on the stone cast with tin foil of a certain thickness or by relief of the impression along the ridge line.

MAXILLARY LESIONS

The upper denture covers a much larger area and is more retentive and stable than the lower denture. However, the basal seat of the maxillary denture is subject to the same variety of soreness, except that it is milder and less persistent.

There are certain zones on and about the palatal vault that are afflicted frequently by sores characteristic of the locale. One of these zones is the torus palatinus (Fig. 1). In former years, large "suction" chambers were placed over the large area of the palatal vault, including the torus. Now the torus palatinus is relieved either on the cast or in the impression, but in most instances the relief is excessive. If no relief were provided for the tori, upper dentures would be more stable because the palatal vault is the most important retentive area for the upper denture (Fig. 2). Furthermore, if the upper ridge is either flat or flabby, the average torus palatinus becomes the most important anchor for stability of the upper denture. However, should the upper denture settle upon its supporting structures (as most dentures do), premature contact between the tissue surface of the denture and the most prominent point of the torus is inevitable.

The denture should be relieved for the torus in the adjustment period, when it is more feasible to determine the amount and rate of settling. Premature contact should be relieved as it appears, but the *physiologic contact* between the torus palatinus and the denture should be fully preserved. This contact can be achieved in two ways: (1) The irritation on the torus is correlated with the corresponding area on

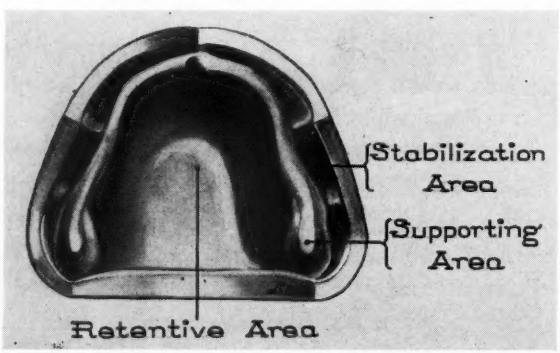



Fig. 2.—Various areas have a controlling influence upon stability and retention of upper dentures. Excessive reduction of the denture surface or borders may lead to complete failure by impairing the adhesion, cohesion, and the effect of atmospheric pressure on these dentures.

the denture by means of an indelible pencil mark and relieved. (2) The irritation on the torus is marked with indelible pencil, and the mark is transferred to the denture. This procedure is more difficult because the pencil mark may not transfer

to the denture, the mark may become smudged, or the color of the pencil and the denture-base material may not be in proper contrast. A small piece of white compound may be added to the dry surface of the denture, brushed with a blow torch

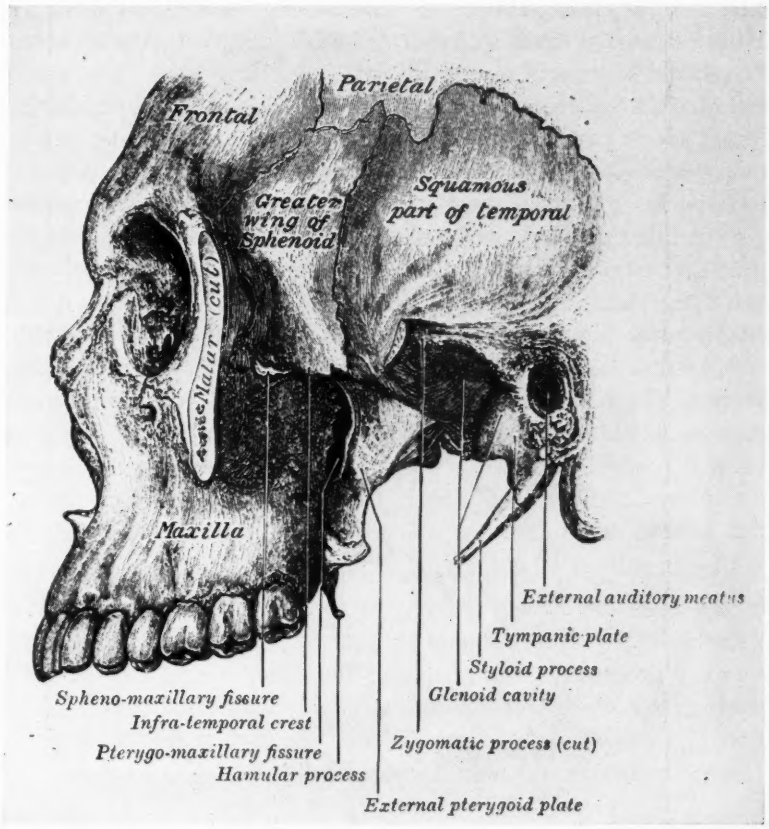



Fig. 3.—Left zygomatic fossa. The posterosuperior denture border should terminate between the distal side of the maxillary tuberosity and mesial surface of the hamular process without overdisplacing the soft tissues situated between these structures. Overextension of the denture border will either loosen the upper denture or injure the soft tissues and cause irritation and ulceration. Tenseness of the pterygomandibular raphe associated with wide jaw separations will dislodge the denture. The same border in an excessively retentive upper denture will cut into the tissues and cause ulceration.

flame, tempered, and pressed quickly against the palate with force. The indelible pencil mark will transfer readily from the hard area to the white compound on the denture base and indicate the premature contact.[2] This method of relieving hard areas is called the *functional method,* i.e., relieving the dentures as their settling progresses in function. The functional method of relieving the torus palatinus is indicated definitely when providing retention and stability of the upper denture represents a serious problem. Relief of the torus by scraping the impression or by placing tin foil on the cast upon which the denture is to be constructed is called the *preventive method.*

The pterygomaxillary or hamular notch, particularly its buccal aspect, also is susceptible to injury (Fig. 3). The use of the indelible pencil is not indicated because its coloring matter mixes with the saliva and obscures the entire field. The localization of the irritated spot is established by careful visual examination; digital examination is of no help because of inaccessibility. Instead, a blunt instrument may be used to locate the exact spot of the initial injury, and only the corresponding limited spot should be reduced on the denture.

Irritation from an overextended denture border in the postpalatal seal area usually causes severe pain because of the continuous mobility of the soft palate during deglutition and mastication and in phonetics. The ulceration is usually oblong, is slitlike in character, and may extend over a large area (from one posterior palatine foramen to the other). The central point of irritation is found usually on the soft palate at the sagittal plane, and this limited spot on the denture requires reduction. Reduction of the denture border all along the area of irritation will make the patient momentarily happier. A few days later, however, the patient will complain that the denture has lost its retention even though it manifested adequate retention after reduction. The reason for this is that the inflamed and edematous tissues at the time of the adjustment prevented the ingress of air at the posterior denture border.

### PROCESSING ERRORS

Since most injuries to the denture-supporting structures are caused by improper occlusion, our attention should always be focused on this important feature of denture prosthesis. No denture should be inserted into a patient's mouth as it comes from laboratory processing. Knowledge of the changes that take place in waxing and processing complete dentures should serve as a warning that every denture must be remounted on an articulator. Occlusion must be corrected until there is harmony between centric occlusion and centric jaw relation.

### ACTION OF THE DENTURE AS A FOREIGN BODY

Dentures may have a disturbing effect upon the oral mucosa merely by their action as a foreign body. Some patients have hypersalivation and others dry mouth or xerostomia soon after they become denture wearers. Cessation of hypersalivation has followed mere discontinuance of wearing the dentures. The biologic principles underlying reflex actions and their stimulation tend to support the thesis that complete dentures may in exceptional instances be a disturbing factor to the oral cavity generally and to the oral mucosa in particular by their mere presence as a foreign body. It is conceivable that the presence of a denture will make some difference in the secretory function, ventilation, and oxidation of the oral structures covered by the denture since they no longer function under perfectly normal conditions. Again, every organ or tissue of the human body is endowed physiologically with self-cleansing properties. Complete dentures certainly interfere to some extent with this process.

Some denture-wearing patients manifest considerable redness of the mucosa covering the palatal vault and upper ridges. If this condition is not associated with

pain or discomfort, it may be considered harmless and as a mild inflammatory process caused by dentures acting as a foreign body.

The disturbances that complete dentures cause as a foreign body are usually within the limits of tolerance of the tissues. Readaptation of the mucosa to a newly established physiologic pattern is the rule. However, different individuals and their tissues react in different ways to the same stimulus. Patients must be individualized in accordance with their reactions, susceptibilities, and idiosyncrasies. Most patients should remove their dentures at night when retiring. However, for some patients the opposite may be desirable because the benefit of resting their oral mucosa is outweighed by other inconveniences they experience. Some people develop wrinkles in their faces when they remove their dentures at night. Others experience severe gagging sensations every morning when inserting their dentures, while they remain free from such experiences if they wear them during sleep. Some people may wear complete dentures for 3 decades with a vertical dimension of occlusion that is extremely short, and yet they have no ill effects. Others must avail themselves of new dentures every 2 or 3 years because of the collapse of the vertical dimension of occlusion. Some patients adjust themselves quickly to tongue placement with dentures while others, under similar circumstances, become handicapped. Some become psychologically adjusted to complete dentures in a brief period of time; other patients never become adjusted. Some patients can masticate anything with complete dentures; others require a special mush diet. It is true that in some instances the handicaps are psychic in nature. However, the patient suffers just as realistically from certain psychic blocks as from reflex actions and neuralgias.

REFERENCES

1. Landa, Joseph S.: Trouble Shooting in Complete Denture Prosthesis. Part III. Traumatic Injuries, J. Pros. Den. **10**:263-268, 1960.
2. Landa, Joseph S.: The Torus Palatinus and Its Management in Full Denture Construction, J. Pros. Den. **1**:236-243, 1951.

136 East 54th St.
New York 22, N. Y.

# MEDICAL SIGNIFICANCE OF EQUILIBRATION OF THE MASTICATING MECHANISM

HERBERT T. KELLY, M.D.,* AND DAVID J. GOODFRIEND, D.D.S.
*Philadelphia, Pa.*

THE MEDICAL SIGNIFICANCE OF EQUILIBRATION of the masticating mechanism concerns the recognition, diagnosis, and treatment of vertigo, which may be caused by defects in the dental occlusion and abnormalities of the mandibular joints. Medical literature attributes vertigo to disease of the ears and eyes, tumor and abscesses of the brain and dura mater, cerebrovascular and cardiovascular diseases, arteriosclerosis, multiple sclerosis, meningitis, infections, toxemias, gastrointestinal diseases, psychoneurotic disorders,[1] and mandibular joint abnormalities.

The medical diagnosis and treatment of vertigo include medical, otologic, neurological, neurotologic, roentgenographic, psychiatric, and surgical procedures. The treatments involve extensive time and discomfort and frequently do not alleviate the vertigo. Thus, the symptomatology of vertigo is complex and often leads to erroneous diagnosis and unsuccessful treatment.

One of the authors (Dr. Herbert T. Kelly) became interested in this subject when he suffered from recurrent attacks of violent, incapacitating, paroxysmal vertigo associated with nausea, vomiting, diarrhea, tinnitus, impairment of hearing, and clicking mandibular joints.

A team of physicians including a neurologist, roentgenologist, encephalogist, otologist, opthalmologist, gastroenterologist, cardiologist, and internist failed to uncover the cause or relieve the symptoms. Goodfriend,[2-6] who had been studying the reflex symptomatology of abnormalities of the masticating mechanism, attributed the vertigo to a disequilibrated masticating mechanism. Dental treatment consisting of rehabilitation and equilibration of the masticating mechanism eliminated the vertigo and the ear and mandibular joint symptoms; there have been no recurrences during the past 6 years.

We have since carried out a medicodental study of the symptomatology and treatment of vertigo.[7] The purposes of this study were (1) to develop methods for the differential diagnosis of vertigo attributable to abnormalities of the masticating mechanism, (2) to determine the statistical incidence of this cause of vertigo in a medical practice, and (3) to test the effectiveness of rehabilitating and equilibrating the masticating mechanism in the treatment of vertigo.

---

Read before the American Equilibration Society, Chicago, Ill.

*Lecturer in Dentistry, Graduate School of Medicine, University of Pennsylvania; Chief of Medicine, Doctors Hospital; Associate in Medicine, Presbyterian Hospital.

## METHODS AND RESULTS

All patients in this study were from a private practice of internal medicine. All had received previous dental treatment which had been acceptable to them and their dentists. Before this study, none were aware that their occlusion was a cause of vertigo.

The medical phase included observation of the teeth and occlusion, palpation of the jaw and mandibular joint movements, and psychosomatic therapy[1] consisting of somatic medication, adequate diet and food supplements, and psychotherapy.

The predental psychotherapy mobilized the patient for the acceptance of the dental procedures as treatment of vertigo. The psychotherapy during dental treatment re-enforced patient cooperation and aided habit modification and adaptation. The postdental therapy altered the previous pattern which associated certain actions, emotions, and fatigue with the onset of the vertigo and overcame the anxiety of recurring attacks.

The fact that vertigo may be caused by many diseases, in addition to occlusion-joint abnormalities, was considered in determining the priority of diagnostic and treatment procedures. The first diagnostic consideration was the elimination of the possibility of intracranial lesions by eye-ground and roentgenographic studies and evidence of facial nerve involvement.

The dental diagnostic phase included case history, temporomandibular roentgenography, and clinical and articulated cast studies. The dental treatment consisted of reconstruction of the upper and lower occlusal surfaces of the teeth to establish joint-ear relationships in accord with the roentgenographic criteria of normality and a harmonious dental occlusion.

During a 6-year period, 102 patients with vertigo have been studied. Seventy-seven patients cooperated in dentoprosthetic rehabilitation coordinated with supportive medical treatment. This treatment completely relieved the vertigo in 70 of the 77 patients. Three patients were partially relieved, and there was no relief in 4 patients. The ages of the treated patients ranged from 8 to 89 years, with an average age of 55 years. Twenty-three patients were men and 54 were women. Thus, 70 per cent of the verified vertigo cases in a private practice of internal medicine were caused by dental occlusion–mandibular joint disharmonies and pathologic conditions. Dentoprosthetic rehabilitation and equilibration of the masticating mechanisms completely relieved the vertigo of 90 per cent of the patients during periods ranging from 2 to 6 years.

These findings represent a significant etiological and treatment factor in the problem of vertigo which requires the understanding and cooperation of the medical and dental professions. The purpose of this article is to contribute to that cooperative understanding.

## SYMPTOMATOLOGY OF VERTIGO

Vertigo is a sense of motion experienced by the individual to be either of his own person or his surroundings, when actually there is no movement of either. This motion need not be a sense of turning as described by the term dizziness, although most frequently it is. Feelings of veering, tilting, or falling also carry the

implication of motion. The sense of motion may be interpreted by the patient as lightheadedness, staggering, giddiness, or dizziness and may be associated with syncope. Since the spatial orientation of a person involves three systems, namely, the vestibular system of the ear, the visual system of the eyes, and the proprioceptive system of the muscles and joints, vertigo may involve disorders of vision, posture, and locomotion.

There are two types of vertigo: (1) peripheral vertigo, involving the vestibular system of the ear, and (2) central vertigo, involving those connections to and from the brain center of equilibrium. Central vertigo is almost always transitory and not severe. It is seldom the intense, paroxysmal symptom complex which is common to peripheral vertigo.[8] Cawthorne[9] found that 93 per cent of 1,523 vertigo patients had the peripheral type.

One type of peripheral vertigo is that which occurs and recurs in episodes, with freedom from discomfort between attacks. Frequently, there are no demonstrable pathologic causes. The duration of the explosive attacks varies from a few minutes to 30 minutes, but longer periods are common. The attacks may be initiated suddenly, without warning or without demonstrable cause. Often, they occur upon arising to get out of bed after a satisfactory night's sleep. After an initial attack of vertigo, there is a greater tendency for attacks to recur with change in posture. Temporary relief may be experienced by recumbency, but this does not always follow. The explosive attacks of vertigo and associated nausea, vomiting, and loss of control represent intensive, incapacitating, frightening situations which convey to the mind of the helpless, anxious patient and his physician the possibility of morbid causes.

On the basis of our findings, a large percentage of these cases may be caused or predisposed by dental occlusion–mandibular joint abnormalities. These include malocclusions of the deciduous and permanent dentitions and retrogressive breakdown and inadequate restoration and replacement of the teeth. The patients' characteristics usually include overclosed, interlocking occlusions and irregular occluding surfaces of the teeth. These may be associated with noisy, painful, and crepitant movements of the mandibular joints and irregular, jerky, limited, or excessive movements of the jaw. Patients usually become accustomed to these dental conditions and learn to eat and speak with them. Thus, these dental occlusion–mandibular joint pathologic conditions are not usually associated with symptoms which would direct the patient or the physician to suspect them as a cause of vertigo.

## CORRELATION OF DENTAL OCCLUSION–MANDIBULAR JOINT PATHOLOGIC CONDITIONS WITH VERTIGO

The vertigo which is caused by disharmonies of the masticating mechanism involves disorders of the external auditory meatus, eardrum, middle ear, ear ossicles, Eustachian tube, and their neurovascularity. Occlusal disharmonies, condylar displacement, and trauma irritate, injure, or otherwise affect these parts of the ear. This results in disorders of impulses to the vestibular system of the ear. The disorders may be an increase or decrease of impulses to the vestibular system of one or both ears. The severity of the vertigo depends upon the degree and suddenness

of the disordered impulses either in the form of excitation or depression. If the impulses are intense and occur suddenly, the vertigo will be more severe than if the disorder is slight and occurs gradually. Individuals respond differently to these

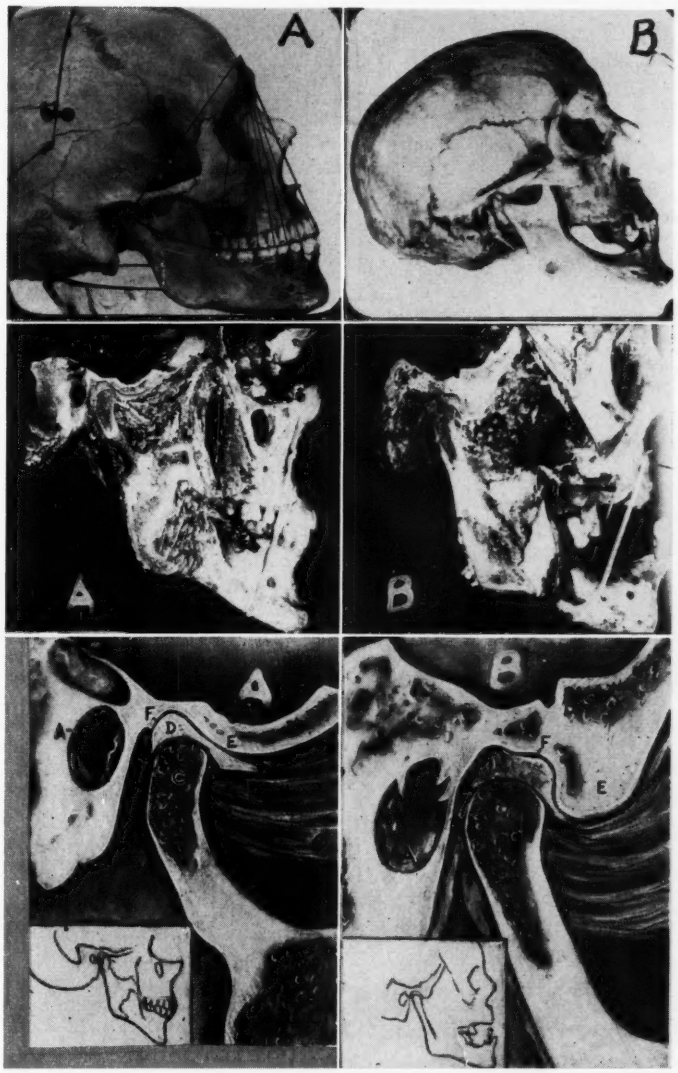



Fig. 1.—Lateral sections of the temporomandibular joint and auditory meatus. *A*, Normal joint-ear form and relationships with normal occlusion. *B*, Abnormal joint-ear form and relationships caused by deteriorated occlusions. These in turn cause vertigo and represent the occlusion-joint pathologic conditions which require prosthodontic treatment.

impulses, as illustrated by varying susceptibility to motion and car sickness and seasickness. The same person may respond differently to the same stimuli under diverse circumstances. This varying susceptibility of the vestibular system has been

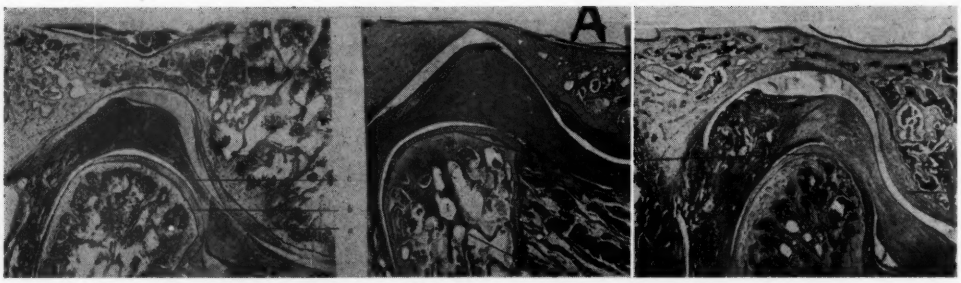



Fig. 2*A*.—Lateral histologic sections of the temporomandibular joint. Normal form, relationships, and tissue structure associated with shallow, flat, and steep-cusped normal occlusions.

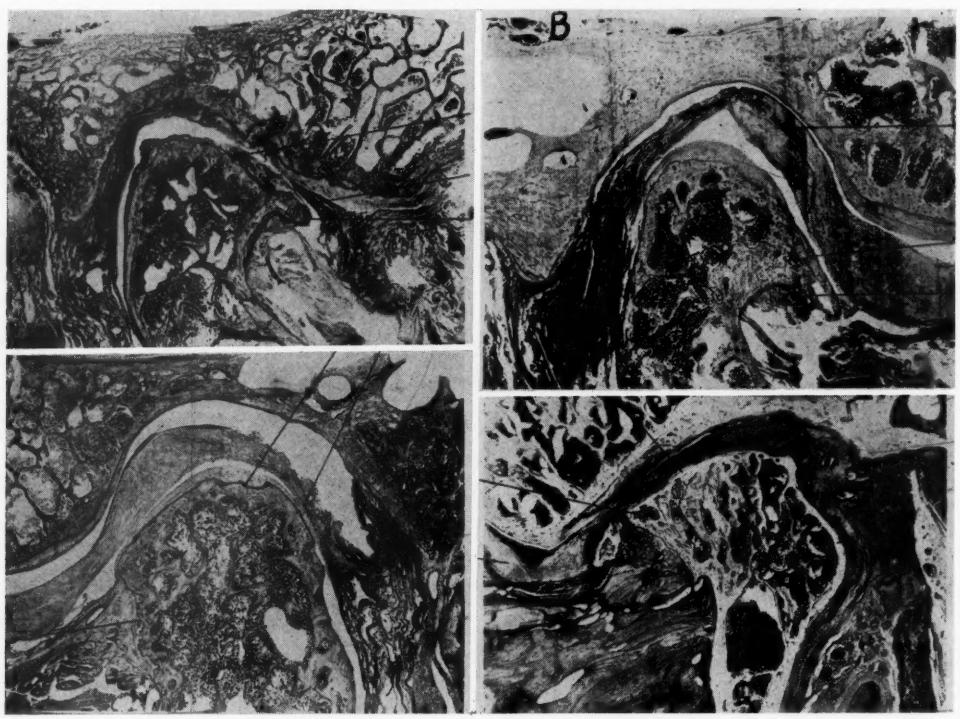



Fig. 2*B*.—Lateral histologic sections of the temporomandibular joint. Malformations, malrelationships, and tissue degeneration, caused by occlusal disharmonies, which result in vertigo.

correlated with dental occlusion–mandibular joint disorders by Kelly and Guild[10] in treating aero-otitis media of submarine personnel and by Wilhelmy[11] working with the Air Force.

These characteristics of vertigo explain the paroxysmal nature and the relative severity of peripheral, as compared with central, vertigo. Peripheral vertigo is likely to be caused by changeable irritants and variable vestibular sensitivity, whereas central vertigo is likely to be caused by an organic pathologic state. This supports our findings which indicate that dental occlusion–mandibular joint conditions cause a large percentage of peripheral vertigo.

The etiological dental occlusion–mandibular joint pathologic states are the result of either developmental or retrogressive disharmonies of the dental occlusion which cause abnormal relationships and traumatic movements of the temporomandibular joints. If these disharmonies occur gradually, they may not cause vertigo even though abnormal relationships of the dental occlusion and temporomandibular joints can be demonstrated. These malrelationships, however, are a potential cause of vertigo, the onset of which may follow psychologic stresses such as anxiety, which increases vestibular sensitivity, and physical stress such as bruxism, which increases the irritation. Frequently, these occur during sleep.

The onset of vertigo in patients with occlusal disharmonies may follow the loss of tooth structure or the insertion of a maloccluded dental restoration. The onset of the vertigo caused by these conditions may not follow immediately after dental treatment but may occur later with the development of a resultant temporomandibular pathologic condition.

Disequilibrium of the masticating mechanism implies occlusal disharmony associated with traumatic malrelationships of the mandibular joints. These factors always occur together and the primary cause is the dental malocclusion.

Lateral views of dry and wet specimens with normal and abnormal masticating mechanisms are seen in Figs. 1 and 2. The normal condition consists of an adequate dentition in normal occlusion which supports normal temporomandibular joint–ear relationships.

The normally occluded condyle is situated in the lower fore part of the fossa (Figs. 1, *A*, and 2*A*). The surface of the eminence of the fossa is smooth, and the space between it and the condyle is occupied by an interarticular fibrocartilage, the thick portion of which is situated in the depth of the fossa. The posterior limit of the fossa is the lip of the petrotympanic fissure. This fissure and the space between the condyle and anterior wall of the auditory meatus is traversed by blood vessels and nerves which supply the joint, auditory meatus, eardrum, and middle ear.

The abnormal masticating mechanism is characterized by an inadequate dentition in traumatic occlusion associated with abnormal temporomandibular joint–ear relationships. The abnormal joint-ear relationships include displacement of the condyle, resorption, and deformity and degeneration of the articular surfaces and tissues (Figs. 1, *B*, and 2*B*).

The normal and abnormal form and relationships of the long axis of the joint and the ear are seen in Fig. 3. The normal condyle is olive shaped with smooth, rounded surfaces and is situated 3 to 5 mm. anterior and lateral to the auditory meatus, middle ear, and Eustachian tube. The posterior and medial bone and cartilage wall of the normal joint is also the anterior and lateral wall of the meatus, middle ear, and Eustachian tube (Fig. 3*A*).

The loss and traumatic occlusion of teeth result in displacement and distortion of the condyle and injury and irritation of the auditory meatus, middle ear, and Eustachian tube (Fig. 3*B*). These disturbances irritate and injure the blood vessels and nerves of the ear which normally traverse the space between the posterior surface of the condyle and these parts of the ear. The resultant irritation, inflammation, and injury of these parts of the ear and their neurovascularity cause

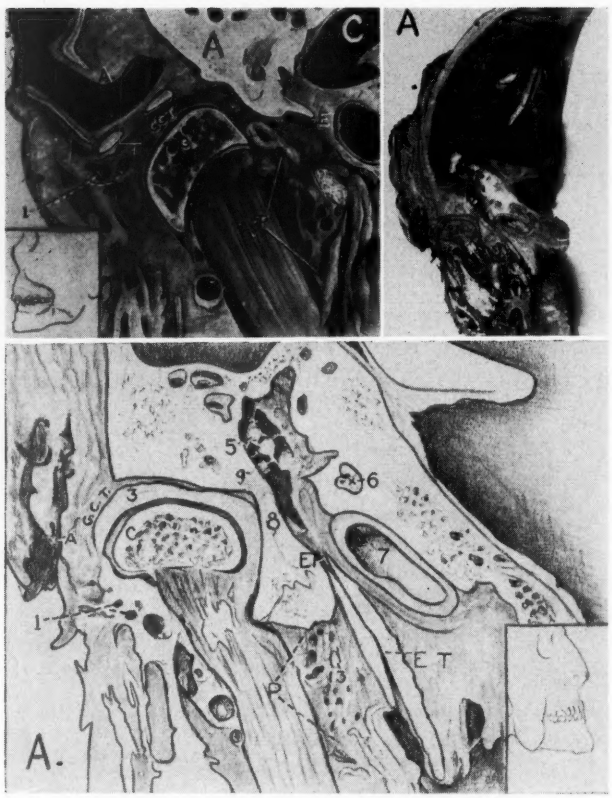



Fig. 3*A*.—Saggital sections through the temporomandibular joint–ear region. The form and relationships of the joint with the auditory meatus (A), middle ear (5, 9), Eustachian tube (ET), osseous eustachian tube (8), internal carotid artery (7), meniscus (3), condyle (C), pterygoid plexus (P), superficial temporal vessels (1), and fold of parotid gland (G.C.T.), which are associated with a normal dental occlusion.

disorders of the impulses to the semicircular canals of the inner ear and thereby cause vertigo (Fig. 4).

Broadbent,[12] Brodie,[13] and Thompson[14] showed that the temporal bone which houses the ear and mandibular joint develops downward, forward, and outward with the eruption and occlusion of the teeth. Goodfriend[5, 6] showed that the normality or abnormality of this development and the resultant form of the joint and its relationship to the ear conform to the occlusion of the teeth. The form of the joints and their relationships to the surrounding structures evolve with the formation of the dental occlusion, retrogress with the deterioration of dental occlusion, and conform to the rehabilitation and replacement of the dental occlusion. These facts are essential to an understanding of the diagnosis and treatment of vertigo. Their application in diagnosis includes consideration of deciduous and developmental malocclusions, as well as retrogressive deterioration and dental traumatogenic causes of vertigo. Their application in treatment includes the fact that abnormal form and relationship of the joint and ear can be normalized by correcting the dental occlusion and temporomandibular relationships.

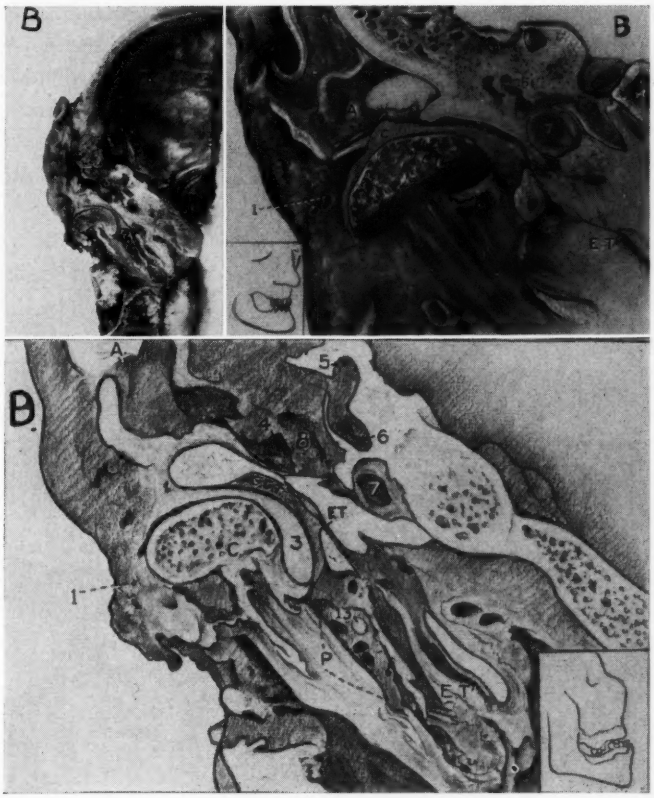



Fig. 3*B*.—Sagittal sections through the temporomandibular joint–ear region. Pathogenic malrelationships of the joint with the meatus (A), eardrum (4), middle ear (8), Eustachian tube (ET), meniscus (3), condyle (C), internal carotid artery (7), pterygoid plexus (P), parotid gland (G.C.T.), and superficial temporal vessels (1), which are caused by dental occlusal disharmonies which cause vertigo.

## DIAGNOSIS OF OCCLUSION-JOINT CAUSES OF VERTIGO

Medical diagnosis is concerned first with the differentiation of peripheral from central vertigo. The absence of symptoms of intracranial pressure by eye-ground studies, negative head roentgenograms, and absence of paralysis indicate peripheral vertigo. The next phase of medical diagnosis consists of clinical examination of the teeth and observation and palpation of the movements of the jaw. Crepitus or other symptoms of the mandibular joints are indications of probable occlusion-joint causes of vertigo.

Present medical diagnosis of vertigo includes extensive otologic, neurological, neurotologic, cephalometric, roentgenographic, and other procedures. These observations frequently involve the patient in traumatic and debilitating experiences. On the basis of the statistical frequency of peripheral vertigo[9] and the high percentage of favorable response to treatment of occlusion, we assumed that the vertigo was caused by occlusion-joint conditions in every patient with negative preliminary medical findings.

The dental diagnosis of occlusion-joint causes of vertigo includes consideration of the depth of the vertical overlap and intercuspation of the teeth, irregularities of the curve and inversions of the plane of occlusion, inadequacy of occlusal support, disharmonies of lateral excursive contacts of the teeth, and abnormal interrelationships of facial and oral landmarks. These conditions are studied clinically and on casts mounted by the face-bow.

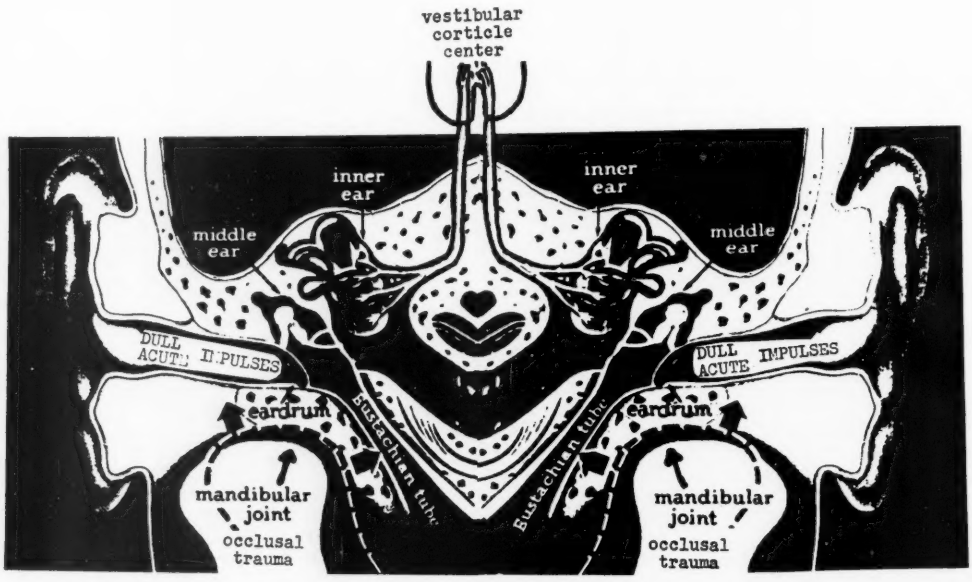



Fig. 4.—A sketch of the temporomandibular joint. The ear relationships show condylar irritation, resulting in increased or decreased impulses to the vestibular system of the ears, which is caused by occlusal disharmony and in turn causes vertigo.

TEMPOROMANDIBULAR ROENTGENOGRAPHY

The joints and their relationships with the ears are studied by means of temporomandibular roentgenography[15] from the lateral and vertex angles using the "spot-focus selector"* (Figs. 5 and 6).

The lateral views show the lateral outline and relationships of the articular eminence, fossa, condyle, and auditory meatus (Figs. 7, 1, *A*, and 2*A*). Departures from the normal, which represent variations of pathogenic abnormalities, are seen in Figs. 9 and 12, *A*.

The vertex views show the outline form and relationships of the long axis of the joint and the auditory meatus, eardrum, middle ear, and Eustachian tube (Figs. 8, 9, 10, and 13). The normal joints associated with normal dental occlusion (Fig. 8) are characterized by a smooth-surface, oval condyle situated 3 to 5 mm. anterior and lateral to the posterior and medial wall of the fossa, which is also the anterior

*Staples-Hoppmann, Inc., Alexandria, Va.

wall of the meatus and the lateral wall of the Eustachian tube. The space between the condyle and the bony fossa-ear wall is traversed by the chorda tympani and branches of the auricular temporal nerves and internal maxillary arteries which supply the joint and the ear. The normality of this space and the neurovascular supply of the joint and ear depend upon the normality of the dental occlusion.

The application of lateral and vertex joint-ear roentgenography in the diagnosis of dental causes of vertigo includes studies of the patient's dental occlusion and duplicate roentgenograms of the joint-ear areas with the occlusion corrected by means of a temporary splint (Fig. 9).

Vertex joint-ear roentgenograms which show the long axis of the joint and its relationships to the auditory meatus, middle ear, and Eustachian tube present the most significant criteria for diagnosing dental causes of ear disorders. These roentgenograms are the most important criteria for determining the degree of occlusal correction which is essential for effective treatment of vertigo. The duplicate roentgenograms of the joint-ear area with the noncorrected and corrected maxillomandibular relationships are valuable assets in diagnosis, prognosis, and guidance of treatment of vertigo. When the pathogenic condition is associated with distortion of the joint-ear outlines (Figs. 10 and 13), the duplicate roentgenograms are used to test the normality of the relationships between the deformed condyle and ear that

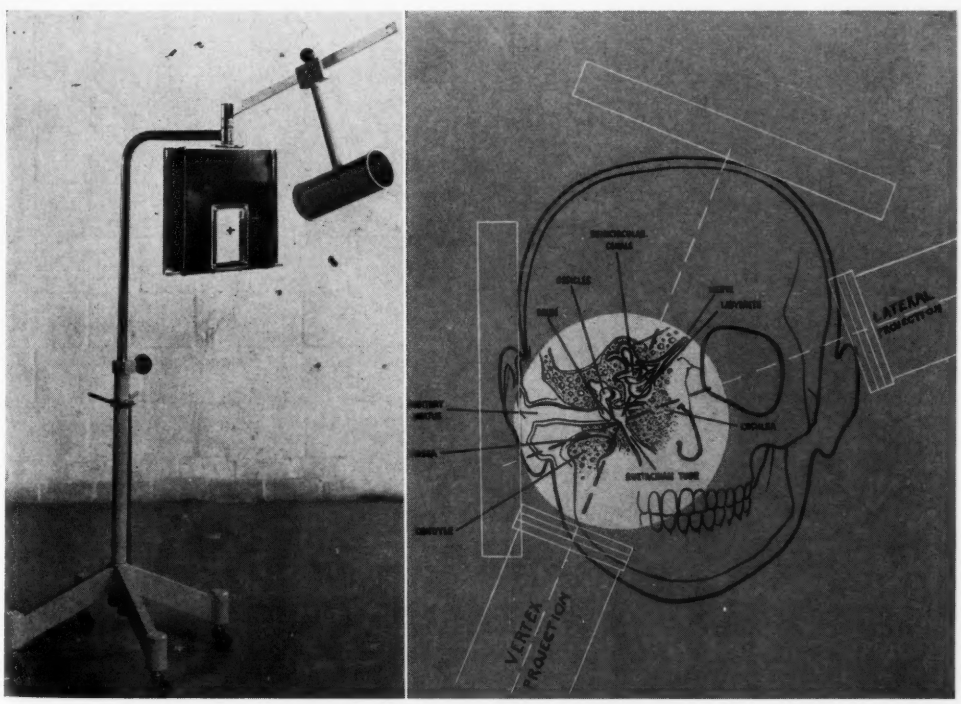



Fig. 5.—The spot-focus selector for temporomandibular roentgenography and a sketch of the direction and parts roentgenographed by lateral and vertex projections. The sketch shows spot-focus provision for multiple, duplicate roentgenograms on a single film and angulation of projections of lateral and vertex temporomandibular joint–ear roentgenograms.

have been established by the temporarily corrected occlusion (Figs. 10, *B*, and 13, *B*). The equilibrated occlusion which establishes normal relationships of the deformed joint results in a normalized form of the joint within a reasonable period after the treatment (Fig. 13, *C*) and relieves the vertigo.

## TREATMENT OF VERTIGO BY EQUILIBRATING MASTICATING MECHANISMS

The prosthodontic treatment of vertigo involves two factors: (1) the relationships of the mandible and its joints and (2) the harmonious articulation of the mandibular joints and the teeth. The former is established by treatment splints in accordance with the temporomandibular roentgenographic criteria. The harmony of dental occlusion with the temporomandibular joints requires reconstruction and replacement of occlusal surfaces in a plane (curvature) of occlusion, which is either continuous or concentric with the condyle paths. This establishes the form and location of the occluding surfaces at the indicated vertical dimension. These surfaces are equilibrated in the patient's mouth to achieve harmony in lateral occlusions in accordance with the principles of Schuyler.[17]

Since the condyle path varies with alterations in the posture of the mandible or in maxillomandibular relationships, the form and location of the occlusal surfaces are of primary importance to occlusal harmony. In this study, the plane (curvature) of occlusion was formed as an arc, the radius of which was the dimension from the mesioincisal point to the condyles. This curvature was located in the interridge and

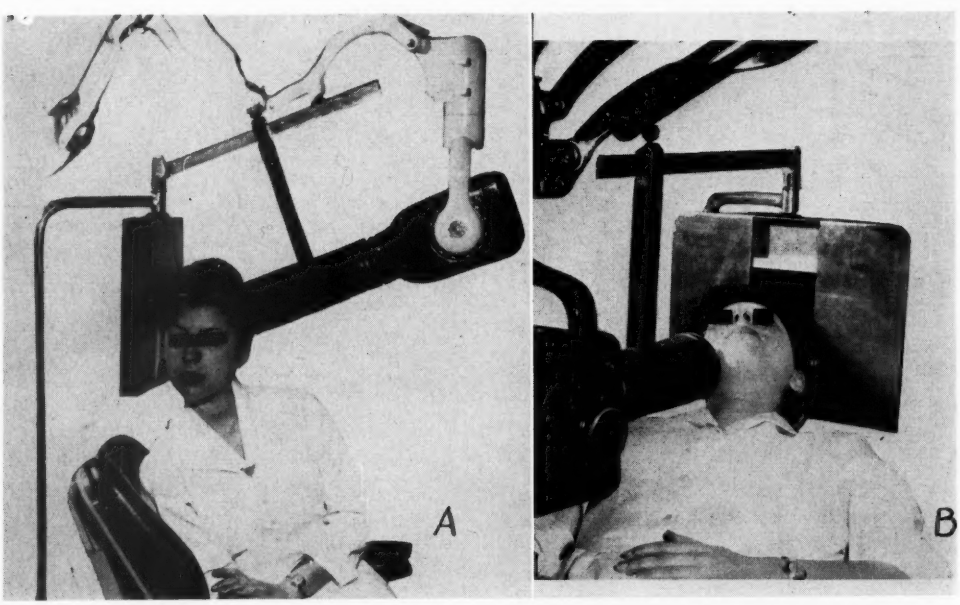



Fig. 6.—Photos of the application of the spot-focus selector in temporomandibular roentgenography. *A*, Lateral roentgenographic technique in which the tragus of the ear is placed in contact with a spot on a plastic window of the cassette sleeve. *B*, Vertex technique in which the gonion and tragus are on a horizontal plane and the tragus is sighted in the outer-center portion of the long tube.

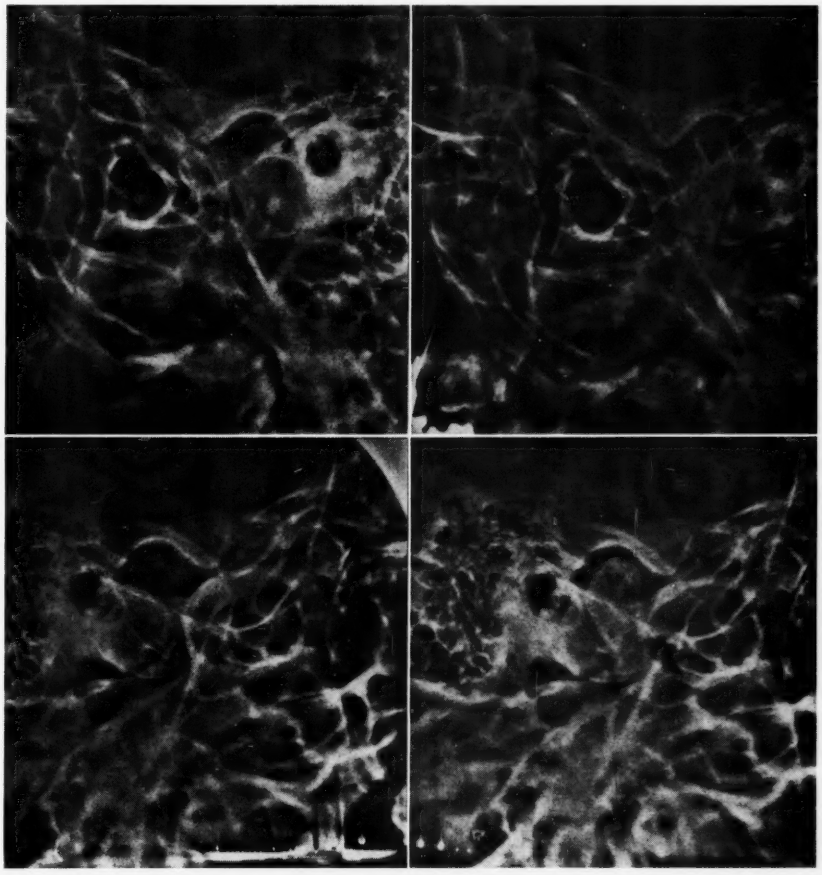


Fig. 7.—The lateral temporomandibular joint–ear roentgenograms provided by the spot-focus selector show the outline and relationships of occluded and opened joints associated with normal occlusion.

interocclusal space so that it passed from the mesioincisal point through or concentric with the condyle path. The mandible in each instance was positioned so the condyle was in the lower fore part of the fossa. This established a shallow path of occlusion and provided the best possible balance and harmony of the occlusal surfaces of the restorations.

Patients with natural teeth were treated with a two-stage procedure. In the first stage, cast-gold or palladium-silver overlays were cemented on the upper and lower, right and left, unprepared premolar and molar teeth (Fig. 11). The overlays were equilibrated to harmonious lateral excursions and worn until the patient was comfortable and had achieved complete relief of the vertigo. If the vertigo was not relieved, the corrective overlays were remade to improve the mandibular repositioning. If this treatment was unsuccessful, the cause of vertigo was considered to be other than the occlusion-joint pathologic condition and the patient was referred for further medical studies.

The second stage of treatment followed the relief of the vertigo. The treatment overlays were replaced by individual onlays and jacket crowns which reproduced exactly the occlusal form and relationships of the overlays.

In completely or partially edentulous patients, the prosthodontic treatment of vertigo was a one-stage procedure. Either complete dentures or a combination of complete and removable partial dentures was constructed to correct the maxillomandibular relationships in accordance with the temporomandibular roentgenograms. The occlusal surfaces were formed and located according to the principles of Kirk.[16]

The overlays and reconstructions were carved with rounded cusps and shallow sulci and marginal ridges but with *no* interlocking of the cusps. In removable partial dentures, remaining and/or abutment teeth were overlayed with castings, either as crowns or as parts of the denture, to conform with the requirements of the

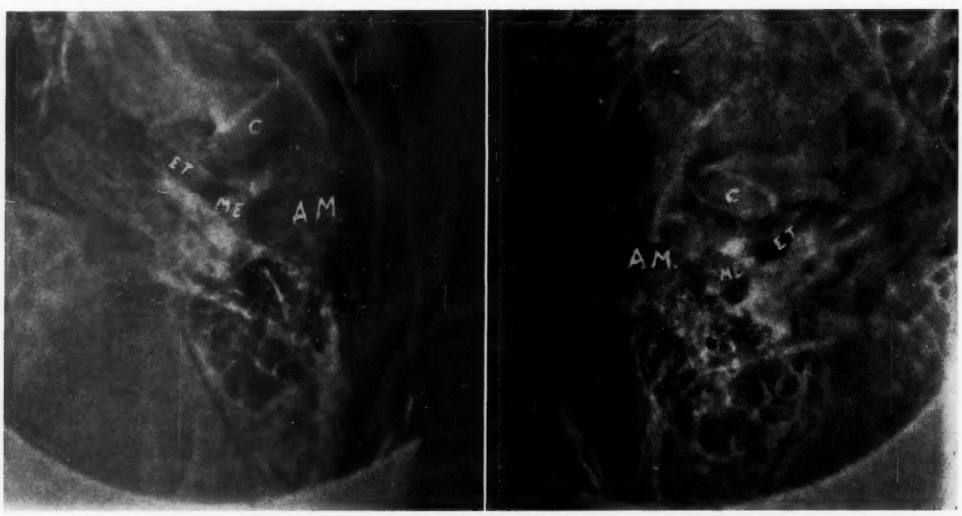



Fig. 8.—Vertex temporomandibular joint–ear roentgenograms provided by the spot-focus selector show the form and relationships of the condyle (C), the auditory meatus (AM), the middle ear (ME), and the Eustachian tube (ET) associated with normal occlusion.

plotted occlusal curvature. Anatomic tooth forms and porcelain teeth were used. Cusps were reduced and rounded to conform with the plotted occlusal curvature and to eliminate intercuspation.

A face-bow was used to mount the casts for every patient. No tracings of condyle movements or lateral excursions were made because during the period in which equilibration of the occlusion is required, the movements of the temporomandibular joints change. When static equilibrium was achieved, the joint-ear results were checked by repetition of the temporomandibular roentgenography (Figs. 12 and 13). These follow-up roentgenograms are essential because the criteria of successful treatment are not only dental comfort, acceptable appearance, and effective mastication, but the elimination of the occlusion-joint cause of the vertigo.

CORRELATION OF PSYCHOSOMATIC AND PROSTHETIC TREATMENT OF VERTIGO

This study showed that the causation of vertigo included sensitivity of the vestibular system and dental occlusion–mandibular joint disharmonies and pathologic states. We found that dental treatment of the organic cause of the auditory disorders was primarily essential for the effective treatment of vertigo. This procedure usually was not, however, readily accepted by the patients. Thus, the first

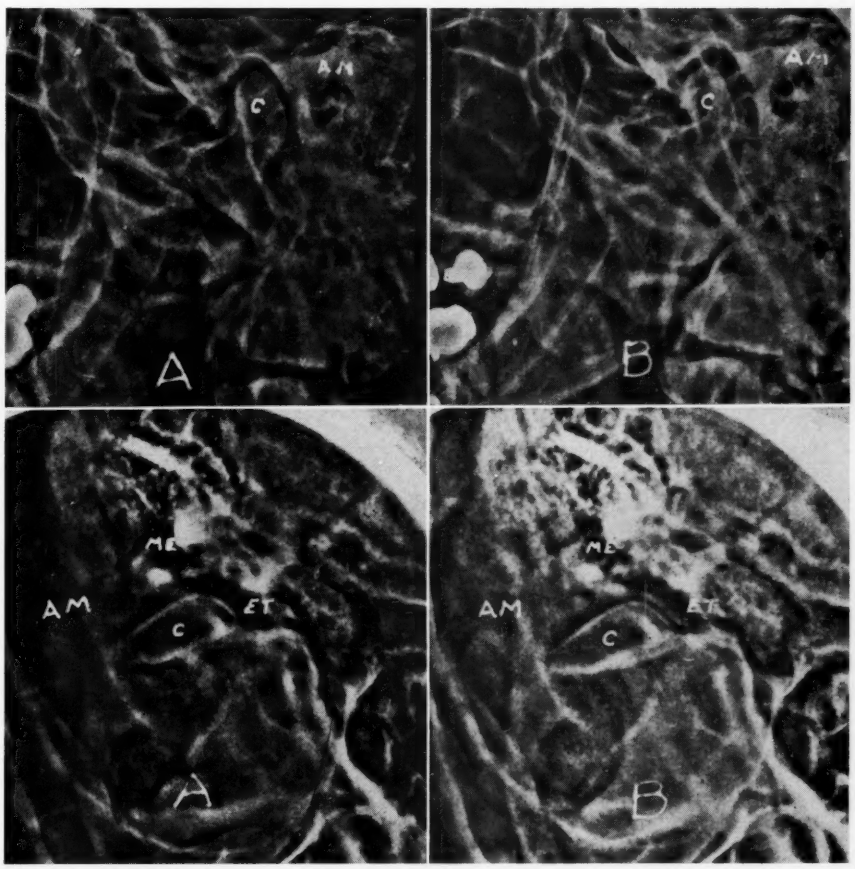



Fig. 9.—The application of lateral and vertex temporomandibular joint–ear roentgenograms. Diagnosis of dental cause of vertigo shows: *A*, The superoposterior pathogenic relationships of the condyle (C) with the auditory meatus (AM) and the Eustachian tube (ET) associated with vertigo caused by the patient's occlusion. *B*, The normal joint–ear relationships of the proposed corrected occlusion shown by duplicate roentgenograms with interposed temporary splints.

phase of treatment was the psychosomatic mobilization of patients for the dental treatment. In some patients, this was accomplished easily, while in others it was very difficult. The treatment consisted of a medical interpretation to the patient of the occlusion-joint pathogenesis of vertigo. This enabled the physician to show the

patient that a comfortable dental situation could cause complex symptoms which to the patient and his previous physician inferred serious etiological pathologic conditions. It was essential to differentiate between the patient's current dental condition and that which was required for the treatment of the vertigo without placing blame or increasing hostility.

Three general types of patients were included in this study. The differentiating factors were the degree and duration of the vertigo and the patient's previous dental

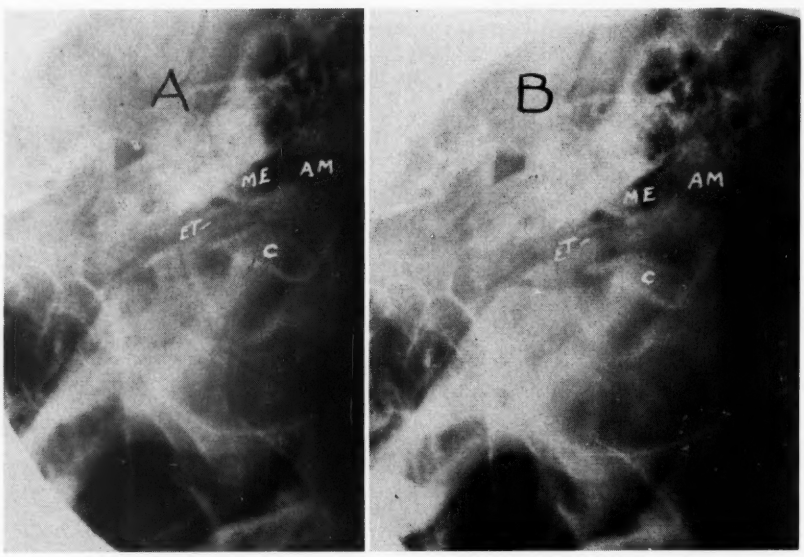



Fig. 10.—Vertex temporomandibular joint–ear roentgenograms show: *A*, A deformed condyle with a medial spur causing abnormal relationships with the middle ear and Eustachian tube, in vertigo resulting from the patient's abnormal occlusion. *B*, Normal relationships of the deformed condyle resulting from the proposed correction of the occlusion for the treatment of vertigo.

and medical experiences. One group had severe, frightening symptoms and traumatic, ineffective medicosurgical-psychiatric treatments for periods up to 17 years. These patients were readily mobilized for dental treatment but required intensive supportive psychosomatic therapy during the dental treatment and periodically thereafter.

A second group had histories of extensive dental treatment which may have contributed to the cause of their vertigo and associated symptoms. They had been through long periods of ineffective dental readjustments and had been shunted to the catch-all category of "psychoneurotics." These were the most difficult patients to mobilize for dental treatment. Their problem included exacerbation of neuroses and the difficult healing of mechanically injured joints.

The third group were those with recent attacks of vertigo. These attacks may have been associated with recent dental treatment or with stressful life situations and long-standing occlusion–mandibular joint pathologic states. The group included

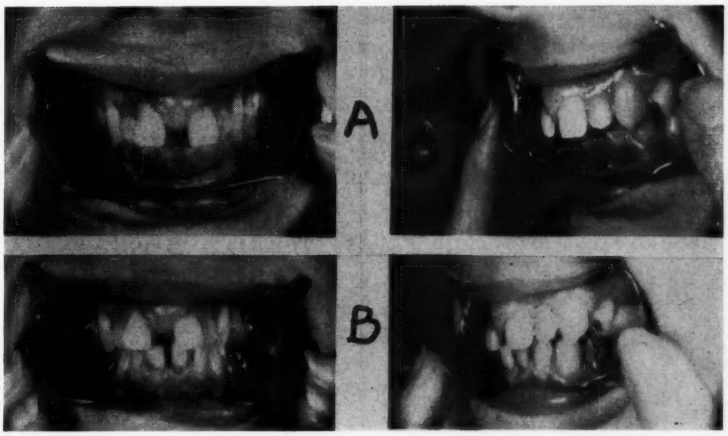



Fig. 11.—*A*, Front and side views of a dental occlusion which caused the joint ear abnormality shown in Figs. 12, *A*, and 13, *A*, associated with severe vertigo. *B*, Front and side views of the occlusion as corrected by overlays of the upper and lower premolar and molar teeth. This resulted in normal joint-ear relationships, illustrated in Figs. 12, *B*, and 13, *B* and *C*.

patients who had become accustomed to their occlusion-joint abnormality but suffered vertgio after the loss of tooth support or with traumatogenic dental restorations exacerbated by bruxism. The reaction of this group to psychosomatic and dental therapy varied.

The psychosomatic and dental therapies were coordinated in this study. The first phase of psychosomatic treatment prepared patients for a comprehensive dental diagnosis. During the dental treatment period, which extended from several months to 2 years, the psychosomatic treatments were directed toward psychologic, nutritional, and somatic rehabilitation. The treatment enabled the patient to accommodate the dental rehabilitation, to alleviate his fears, and to cope with stressful situations and it worked to medically diminish vestibular sensitivity.

While the vertigo of some patients who did not cooperate with psychosomatic treatment was relieved by the dental treatment, they retained anxieties and memory symptoms. These symptoms were relieved in patients who completed the psychosomatic program.

The best results in the treatment of vertigo attributable to occlusion–mandibular joint pathologic conditions and psychologic factors were achieved by reciprocal cooperation of dental treatment and psychosomatic therapy. The reciprocity consisted of first establishing an understanding of the psychosomatic problem by the physician and of the dental problem by the dentist, with the further understanding that neither would trespass upon the prerogatives of the other. Frequently in psychotherapy, the patient's hostility was turned upon the physician or the dentist. Reciprocal dentopsychosomatic therapy required that each therapist listen attentively to patients' complaints about the other and maintain a neutrality limited to an assured nod of his head. The important need is for the patient to purge himself of hostility by talking it out. However, there can be neither encouragement by agreement nor discouragement by disagreement.

Treatment of vertigo involves the correction of a two-phase cause. These phases are (1) the sensitivity of vestibular response and (2) the irritation of the ear and Eustachian tube by the displaced condyle and traumatogenic malocclusion. The margin of safety of the correction of these pathogenic factors is slight, and patients are likely to remain susceptible to recurrence by their original causes. The causes include stressful life situations and emotional fatigue, which increase vestibular sensitivity, and jaw clenching and bruxism, which increase condyle displacement and trauma. An initial attack of vertigo is likely to establish a pattern of susceptibility

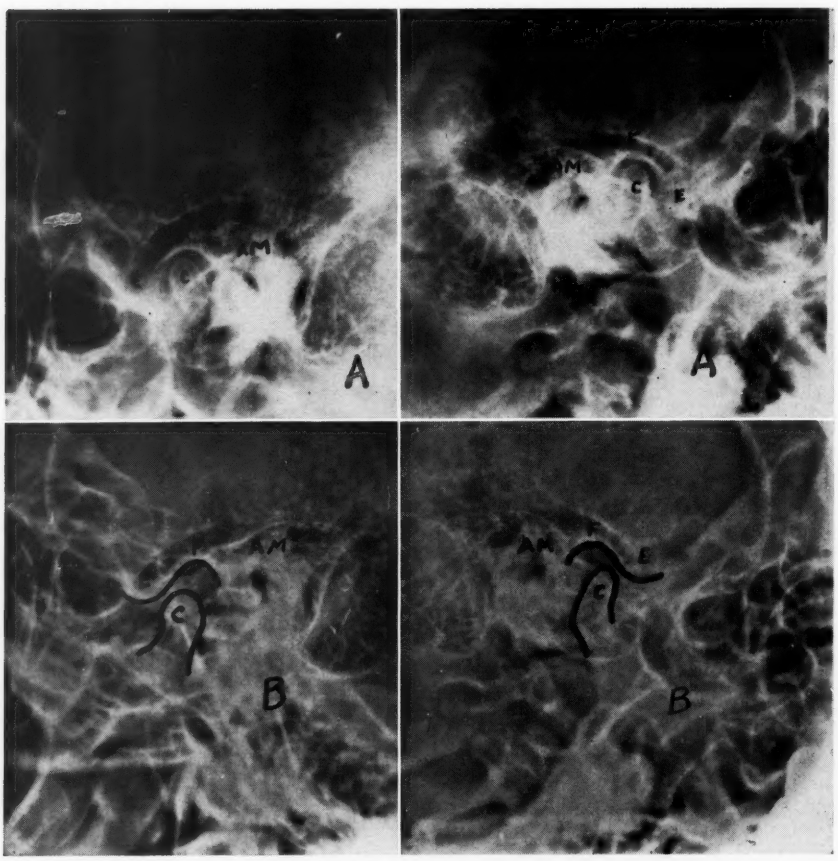



Fig. 12.—Lateral temporomandibular joint roentgenograms before and after equilibration of the masticating mechanism. *A*, Right and left joints with the condyles (C) situated superoposteriorly in abnormally deep fossae with steep, irregular fossa eminence curves (FE) and pathogenic contact between the condyles (C) and the sclerosed auditory meatuses (AM). *B*, The normal form, posture, and relationships of the condyles (C), fossa eminences (FE), and auditory meatuses (AM) after 6 months of treatment by equilibration of the occlusion that established normal temporomandibular joint relationships.

to recurrence. Since it is likely that habits cannot be modified completely and that stressful situations cannot be eliminated, it is advisable to include a program of

psychologic, nutritional, and somatic medical supervision, with periodic temporomandibular roentgenograms and equilibration of occlusions.

SUMMARY

1. This article reports a 6-year medicodental study of the dental occlusion–mandibular joint cause and the dentopsychosomatic treatment of vertigo. Vertigo is a serious symptom complex which includes sudden attacks of dizziness, nausea, violent vomiting, blackout, and loss of consciousness.

2. Of 102 patients studied, the vertigo in 77 was attributable to occlusion-joint causes. Dentopsychosomatic treatment resulted in complete relief of the vertigo of 70 of 77 (90 per cent) of the patients treated for periods of 2 to 5 years.

3. The occlusion-joint causes of vertigo were displacement and traumatic movements of the condyles caused by occlusal disharmonies associated with the attrition, loss, malocclusion, and inadequate restoration and replacement of teeth.

4. The diagnostic procedures included clinical observation, studies of mounted casts of the occlusion, and lateral and vertex roentgenographic studies of the temporomandibular joint–ear regions.

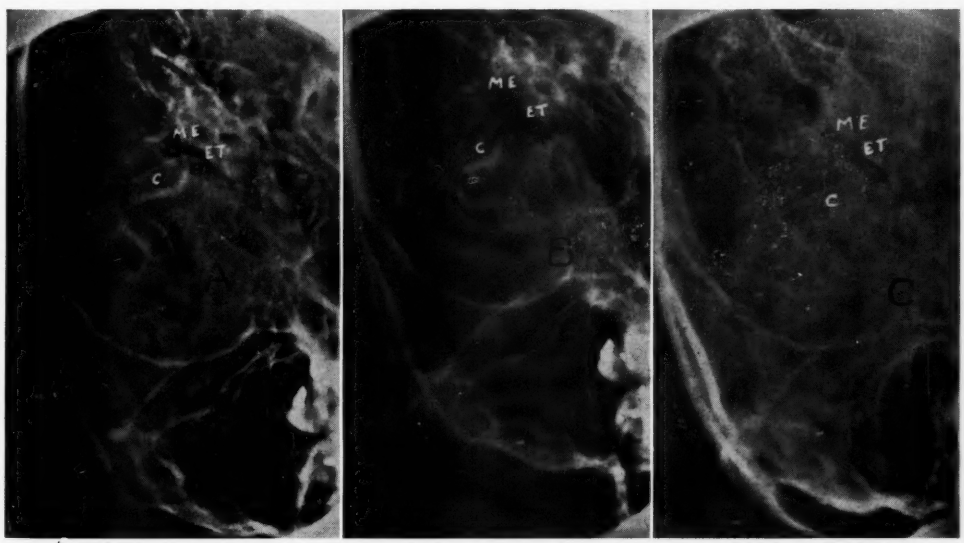



**Fig. 13.—Vertex roentgenograms of the joint-ear region. *A*, A deformed, displaced condyle with a medial spur in pathogenic relationship with the Eustachian tube and middle ear. This was caused by an aggravated Class II malocclusion and was associated with severe vertigo of 10 years' duration. *B*, A duplicate roentgenogram with occlusion corrected by a temporary splint and the resultant normalized relationships of the deformed condyle with the Eustachian tube and the middle ear. *C*, A duplicate roentgenogram made 6 months after completion of an equilibrated normal occlusion which resulted in normal condyle form and normal relationships of the condyle to the middle ear and the Eustachian tube and which provided relief of vertigo.**

5. The effective dental treatment of vertigo consisted of reconstruction and replacement of teeth to establish normal joint-ear relationships in accord with the

criteria of temporomandibular roentgenography and a harmonious occlusion in accord with the principles of Kirk.[16]

6. Effective psychosomatic treatment of vertigo was coordinated with the dental treatment to mobilize the patient to cooperate with dental treatment of vertigo, to support the patient during dental treatment, to reduce vestibular sensitivity, and to alleviate anxiety.

## CONCLUSIONS

The solution of a large segment of the vertigo problem lies within the cooperation of the physician and dentist. The holistic viewpoint of medicodental responsibilities includes the extent of vertigo in medical practice, its threat to the health and security of the patient and his family, its present confused status in medicine, the high percentage of dental causation, and the effectiveness of dentopsychosomatic treatment of vertigo.

Seventy-six per cent of the vertigo cases in a private practice of internal medicine was attributable to dental conditions which were acceptable to the patients and considered nonpathogenic by previous dentists. These dental conditions caused vertigo by condylar irritations of the ear which resulted in disorders of the vestibular systems. The vertigo of 90 per cent of the patients was completely relieved by dental treatment which established normal temporomandibular relationships and a harmonious occlusion, when it was given in cooperation with psychosomatic, supportive medical treatment.

From the dental viewpoint, vertigo presents an opportunity to prevent and treat a serious medical disability. The dentist must assume responsibility for normal temporomandibular relationships and harmonious occlusion in orthodontic, operative, and prosthodontic procedures.

From the medical point of view, the high percentage of vertigo which is attributable to occlusion-joint causes and the high percentage of effectiveness of dentopsychosomatic therapy indicate that the physician should consider these factors early in the diagnosis and treatment of vertigo.

## REFERENCES

1. Kelly, H. T.: Psychosomatic Aspects of Prosthodontics, J. Pros. Den. **5**:609-622, 1955.
2. Goodfriend, D. J.: Disarthrosis and Subarthrosis of the Mandibular Articulation, D. Cosmos **74**:523, 1932.
3. Goodfriend, D. J.: Symptomatology and Treatment of Abnormalities of the Mandibular Articulation, D. Cosmos **75**:844, 947, and 1106, 1933.
4. Goodfriend, D. J.: Abnormalities of the Mandibular Articulation, J.A.D.A. **21**:204, 1934.
5. Goodfriend, D. J.: The Role of Dental Factors in the Cause and Treatment of Ear Symptoms and Diseases, D. Cosmos **78**:1292, 1936.
6. Goodfriend, D. J.: Deafness Tinnitus Vertigo and Neuralgia, Arch. Otolaryng. **46**:1, 1947.
7. Kelly, H. T., and Goodfriend, D. J.: Vertigo Attributable to Mandibular Joint-Dental Bite Abnormalities, (Abstract), J. Am. Col. Den. **24**:182-186, 1957.
8. Alpers, B. J.: Vertigo and Dizziness, New York and London, 1958, Grune & Stratton, Inc.
9. Cawthorne, F., Aural Vertigo, *in* Ellis, M., editor: Modern Trends in Diseases of the Ear, Nose and Throat, New York, 1954, Paul B. Hoeber, Inc.
10. Kelly, W. J.: Research Project X-434, New London, Conn., 1956, Medical Research Dept., J. S. Submarine Base.
11. Wilhelmy, G. E.: Personal Communication.
12. Broadbent, B. H.: The Face of the Normal Child, Angle Orthodont. **7**:209, 1937.

13. Brodie, A. G.: On Growth Pattern of Human Head, Am. J. Anat. **68**:15, 1941.
14. Thompson, J. R., and Brodie, A. G.: Factors in the Position of the Mandible, J.A.D.A. **29**:925-941, 1942.
15. Goodfriend, D. J., and Kelly, H. T.: Temporomandibular Joint Criteria in Dentoprosthetic Rehabilitation, J.A.D.A. **60**:197-210, 1960.
16. Kirk, E. C.: A New Standard for Cranial Study in Relation to the Dentures, D. Cosmos **71**:297, 1929.
17. Schuyler, C. H.: Correction of Occlusal Disharmony of the Natural Dentition, New York State D. J. **13**:445, 1947.

1900 Spruce St.
Philadelphia 3, Pa.

901 Medical Arts Bldg.
Sixteenth and Walnut Sts.
Philadelphia 2, Pa.

---

Wisdom

"And the Emperor of China said to his ministers, 'Go search through the land for the wisest of my subjects, he who hath the greatest knowledge and the highest ability to use it. And when he is found, bring him to me. And he shall be my adviser and sit at my right hand.' And the ministers searched through the land and found him and brought him to the Emperor. And with him came one other. And the Emperor welcomed the wisest of his subjects and gave him great honor. 'But,' asked the Emperor, 'who is this other one who comes with you?' And the wisest of the Emperor's subjects answered, 'This was my teacher.' "

*From* The Halls of Ivy, *"Dr. Hall's Book," courtesy of the author, Mr. Don Quinn.*

# PHYSICAL PROPERTIES OF DENTURE-BASE MATERIALS

JOHN A. CORNELL, B.S., M.S.,* JOHN L. TUCKER, B.S.,* AND CATHERINE M. POWERS*
*Philadelphia, Pa.*

A NUMBER OF INVESTIGATORS have examined the properties of denture-base materials. Many papers refer to practical use and preparation techniques.[1-3] Others refer to physical properties such as dimensional stability, transverse deflection, water sorption, and solubility, all of which are important tests for denture-base materials.[1,4,5,7,8] In addition, further studies refer to the use of tests for the evaluation of plastics in general, such as Charpy and Izod impact, tensile strength, heat distortion temperature, compressive strength, and various types of hardness tests.[6-9] None of the above tests or techniques will define a successful denture-base material, but they can eliminate those with unsatisfactory properties. It is of particular importance to have a denture-base material which resists breakage.

In a previous article,[10] we discussed tensile testing of various methyl methacrylate polymers and the effect of varying the speed of elongation. It was found, as is shown in Fig. 1, that at high rates of elongation increased crosslinking decreased the tensile strength. In our 1957 article[11] describing flexure testing, it was shown that a crosslinked sample broke sooner than a comparative noncrosslinked sample. There did not appear to be any fatigue or aging involved, as indicated by the solid line in Fig. 2. The dotted line is representative of a fatigue curve. Failure in both these cases probably involved edge flaws, which are sites of initiation of breakage. Methyl methacrylate polymer is particularly susceptible, under stress, to rapid propagation of the initial split.

An important property of a denture base is its ability to resist breakage under impact. The patient is interested not so much in what the energy of the break is but whether a break occurs. With this thought in mind, we investigated a falling ball test in which the energy may be dissipated without breakage. It would have been possible to use a Charpy or Izod test at loadings which would break only a part of the samples.

We have studied how various compositions affect impact resistance as measured by a falling ball test. Using polymethyl methacrylate as a standard composition, we have investigated the effect of using crosslinking agents, plasticizers, and fillers. The effect of moisture was determined on some compositions. Tests were also run using samples cut from commercial cast sheet.

---

Read at the 36th General Meeting of the International Association for Dental Research, Dental Materials Group.

*Polymer Research Department, H. D. Justi & Son, Inc.

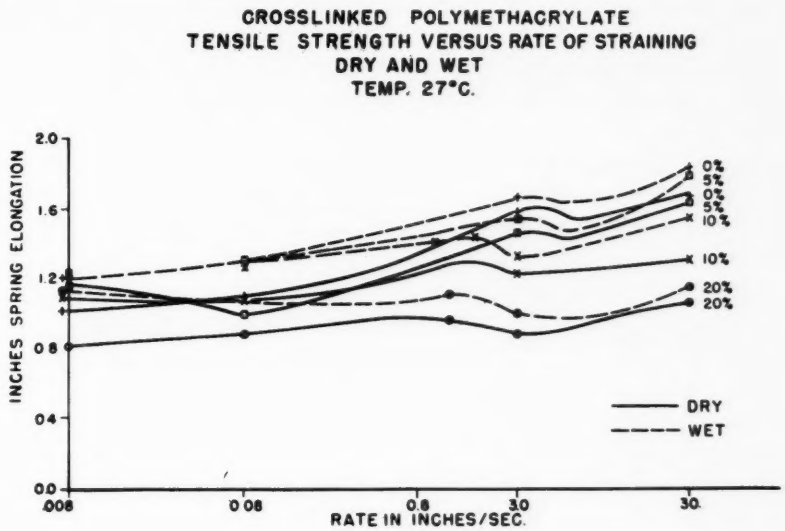



Fig. 1.

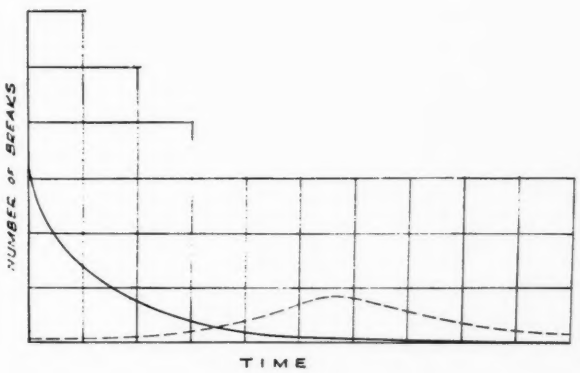



Fig. 2.

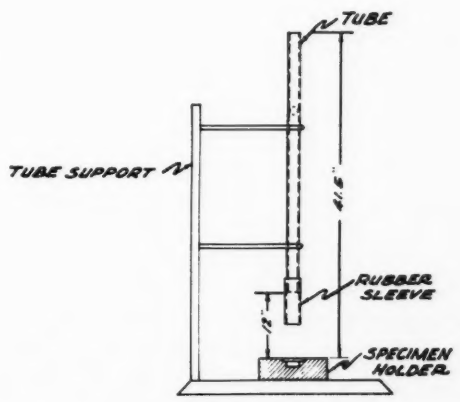



Fig. 3.

## EXPERIMENTAL TECHNIQUE AND DATA

Fig. 3 is a drawing of the instrument used for the falling ball impact test. This is simply a supported brass tube of slightly larger internal diameter than the ball.

Table I gives the specifications for the test. We have chosen a velocity of impact similar to that attained in dropping a denture. A ball was chosen of sufficient weight to break a high percentage of standard samples in one blow at this height. The ball is dropped repeatedly on the same sample until breakage occurs. A sample size of convenient diameter for uniform molding by dough technique and of the approximate thickness of a denture was chosen.

A dough mix was packed in the usual manner, molded in a five-cavity stainless steel mold, and cured in an electrically heated Carver press (room temperature to 98° C. in 20 minutes; held at 98° C. for 10 minutes.) Cooling water was then circulated through the platens for 15 minutes. The curing time is much less than that used in the dental laboratory, but because of the high heat conductivity of the metal mold it was found by a residual monomer test and a Rockwell hardness test that polymerization was essentially complete.

TABLE I. FALLING BALL IMPACT TEST SPECIFICATIONS

| | |
|---|---|
| Size of ball | 0.812 in. (2.06 cm.) diameter |
| Weight of ball | 35.5 Gm. |
| Height of drop | 41.5 in. (105 cm.) |
| Specimen size | 1.5 in. (3.81 cm.) diameter<br>0.135 in. (0.343 cm.) thick |
| Size of ledge around entire circumference for support of specimen | 0.125 in. (0.3175 cm.) deep |

In plotting the data, the percentage of samples unbroken is plotted against the cumulative number of blows. The shaded portion at the top of some of the bars indicates the variation between two sets of tests. The minimum number of samples run for each composition variable was 100.

Fig. 4 indicates the impact resistance of the standard polymethyl methacrylate–methyl methacrylate monomer composition. Note on this graph that after one blow 64 to 78 per cent of the samples remained unbroken. After five blows 34 per cent of the samples were unbroken. After 25 blows 5 to 6 per cent were unbroken, and after 50 blows only 1 per cent remained unbroken.

## EFFECT OF CROSSLINKING

Since crosslinking agents are used to increase the solvent resistance of polymethyl methacrylate, we investigated their effect on impact resistance.

Fig. 5 indicates the impact resistance of a 5 per cent crosslinked composition. This shows about the same percentage of unbroken samples after one blow as the noncrosslinked; however, there is an increase in the percentage remaining after five blows.

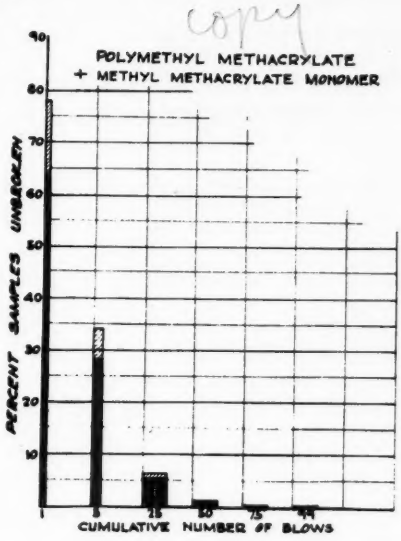



Fig. 4.

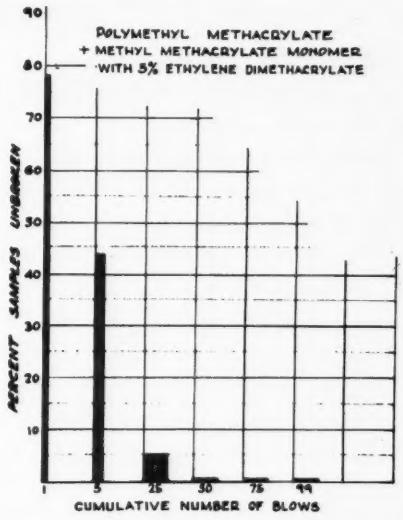



Fig. 5.

In Fig. 6, with a 10 per cent crosslinked composition, we have a very significant increase over the entire range. Whereas in the noncrosslinked material we have about 70 per cent remaining unbroken after one blow, in this composition we have 96 per cent remaining; after 50 blows, instead of 1 per cent we have 44 per cent. Even after 99 blows we have 10 to 15 per cent remaining unbroken. Each sample was subjected only to 100 blows, and if breakage did not occur the test was stopped.

Twenty per cent crosslinking shows no marked change from the previous, 10 per cent crosslinked material (Fig. 7).

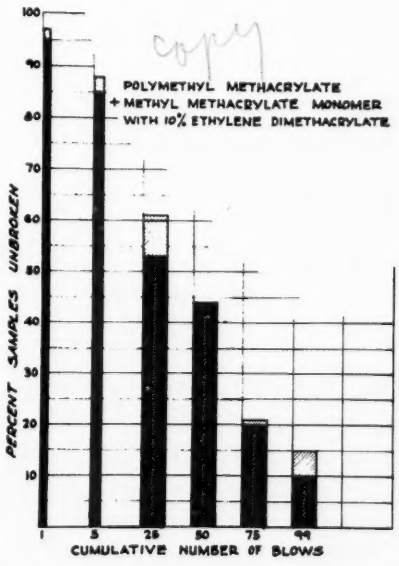



Fig. 6.

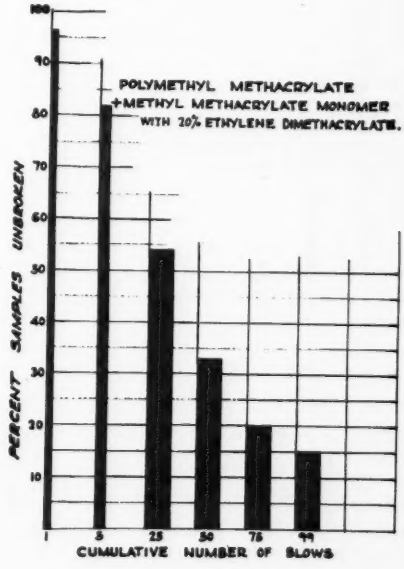



Fig. 7.

EFFECT OF MOISTURE

Since dentures are used in a moist atmosphere, we are interested in impact resistance under these conditions. The effect of water soaking is shown in Figs. 8 and 9.

When the noncrosslinked samples were stored in water at 37° C. for 1 week, the percentage unbroken after one blow dropped from 70 to 48 per cent, and there were no samples remaining unbroken after only 25 blows.

When the 10 per cent crosslinked samples were water soaked for 1 week at 37° C., a similar effect was observed—the percentage remaining unbroken at one blow was only 62 instead of 98 per cent. After 25 blows, there is only 1 per cent remaining instead of 60 per cent for the same composition stored dry.

Fig. 10 gives a comparison of the above results, plotting only the percentage of samples remaining unbroken after one blow.

This would indicate that crosslinking of 10 per cent or higher improves impact resistance. The samples soaked in water for 1 week show a considerably lower impact resistance than the corresponding dry composition.

EFFECT OF PLASTICIZERS

Plasticizers are frequently used to improve working properties of a denture-base material, so their effect on impact resistance was studied.

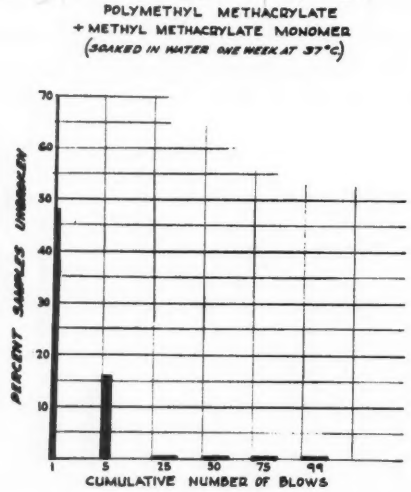



Fig. 8.

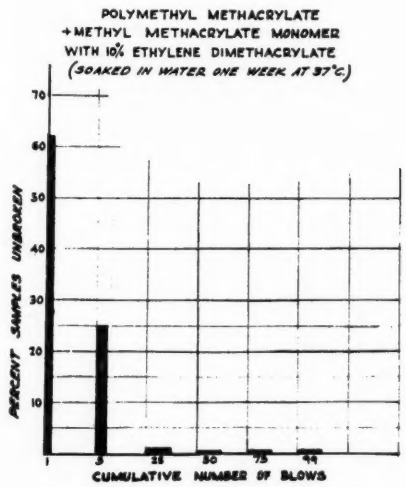



Fig. 9.

Comparing the plasticized polymer to a pure polymethyl methacrylate, Fig. 11 indicates a slight lowering of impact resistance.

When a plasticized polymer is used with a 10 per cent crosslinked monomer (Fig. 12), again it is indicated that a plasticized crosslinked material has considerably lower impact resistance than a corresponding unplasticized material.

The two tests shown in Figs. 13 and 14 determine the effect of plasticizing the monomer rather than using a plasticized polymer. The amount of plasticizer in the

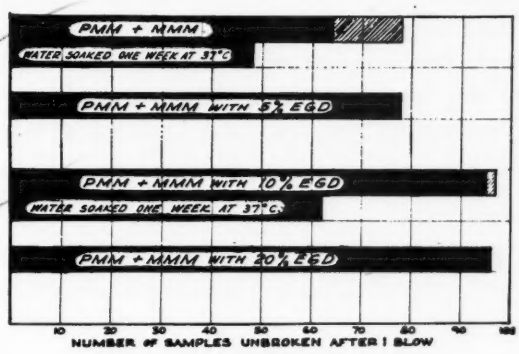

PMM + MMM
WATER SOAKED ONE WEEK AT 37°C
PMM + MMM WITH 5% EGD
PMM + MMM WITH 10% EGD
WATER SOAKED ONE WEEK AT 37°C
PMM + MMM WITH 20% EGD
10 20 30 40 50 60 70 80 90 100
NUMBER OF SAMPLES UNBROKEN AFTER 1 BLOW

Fig. 10.

monomer is 10 per cent but is the same in the final composition as a 5 per cent plasticized polymer. Fig. 13 indicates that only a slight change in impact resistance is caused by plasticizing the monomer rather than the polymer. Fig. 14 also indicates that only a slight change in impact resistance results from plasticizing the monomer rather than the polymer, when a crosslinked material is used in both cases.

The composition considered in Fig. 15 was a variation in the class of plasticizer. There appears to be no significant difference in impact resistance when either dibutyl phthalate or dibutyl sebacate is used as the plasticizer (i.e., aliphatic, aromatic, or aliphatic-aromatic).

Fig. 16 is a composite showing the effect of plasticizers at one blow. This points out that plasticizing the material (either the polymer or the monomer) tends to decrease the impact resistance.

Other data show that in a test carried out on a 5 per cent dibutyl phthalate plasticized polymethyl methacrylate using methyl methacrylate monomer with 10 per cent ethylene dimethacrylate and water soaking the samples for 1 week at 37° C., the result was 59 per cent unbroken after one blow. As you will remember

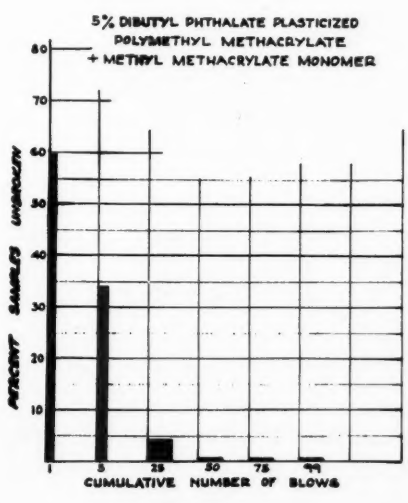



Fig. 11.

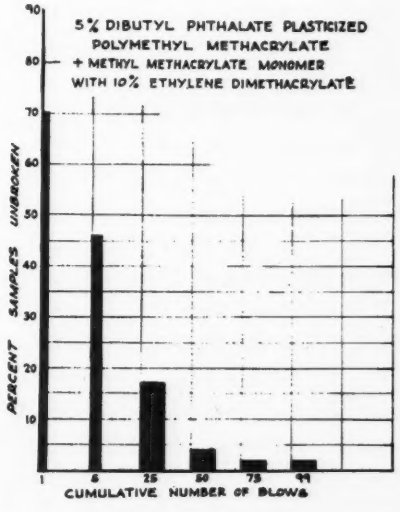



Fig. 12.

from Fig. 16, the plasticized-crosslinked composition stored dry showed 70 per cent unbroken after one blow, whereas water soaking for 1 week reduced this to 59 per cent unbroken after one blow. It is therefore indicated that the smallest decrease in impact resistance by water soaking occurred in the plasticized-crosslinked composition. In fact, the percentage of samples remaining unbroken after one blow is the same for the plasticized and nonplasticized crosslinked material after water soaking. This may indicate that by soaking in water materials absorb moisture, which is a similar effect to plasticizing them, thus lowering the impact resistance.

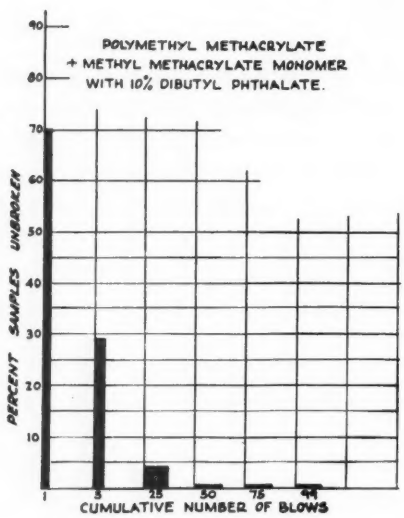



Fig. 13.

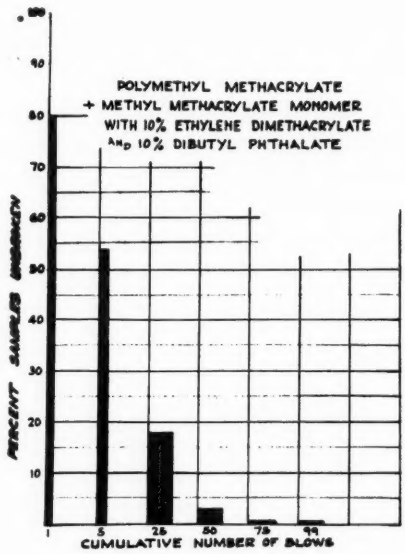



Fig. 14.

FILLED COMPOSITIONS

Tests were run using the standard polymethyl methacrylate–methyl methacrylate monomer composition but adding the following fillers to the polymer in the stated percentages:

40 per cent Fiberglas
20 per cent Fiberglas
20 per cent silica (325 mesh)
20 per cent aluminum oxide (400 mesh)

The results of these tests were not plotted since all 100 samples of each of the above compositions broke on the first blow.

It is believed that the decreased impact resistance of the filled materials results from poor bonding of the plastic to the filler.

CAST SHEET

Samples were cut from Rohm & Haas standard Plexiglas sheet and subjected to the falling ball test. The result was the same as with the filled materials above, in that all of the samples broke on the first blow.

## CONCLUSIONS

Our conclusions from evaluations of falling ball tests on dough compositions of dental interest are:

1. Crosslinking of the monomer improves impact resistance notably when 10 or 20 per cent ethylene dimethacrylate is used.

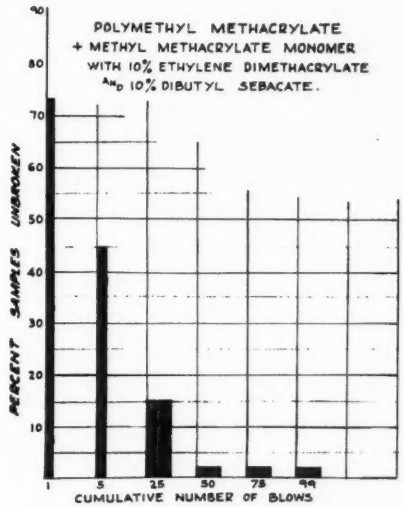



Fig. 15.

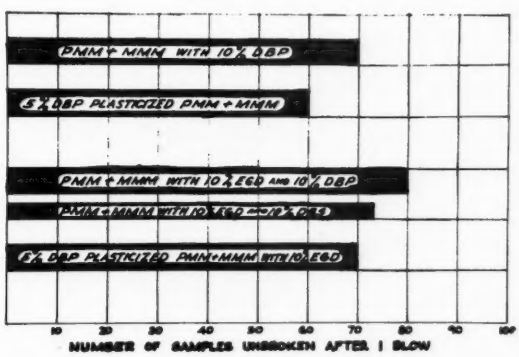



Fig. 16.

2. Plasticizers do not appear to improve impact resistance. In fact, contrary to what might be expected, there is a decrease in impact resistance.

3. Samples soaked in water for 1 week have lower impact resistance than comparative compositions stored dry.

4. Plasticized water-soaked compositions show less decrease in impact resistance than comparable nonplasticized water-soaked compositions.

5. The filled compositions that were tested had a drastically lower impact resistance than the corresponding nonfilled polymethyl methacrylate.

6. Samples cut from commerical cast sheet have poor impact resistance compared to a dough-packed composition.

REFERENCES

1. Grunewald, A. H., Paffenbarger, G. C., and Dickson, G.: The Effect of Molding Processes on Some Properties of Denture Resins, J.A.D.A. **44**:269, 1952.
2. Harman, I. M.: Effects of Time and Temperature on Polymerization of a Methacrylate Resin Denture Base, J.A.D.A. **38**:188, 1949.
3. Peyton, F. A.: Packing and Processing Denture Base Resins, J.A.D.A. **40**:520, 1950.
4. Swaney, A. C., Paffenbarger, G. C., and Caul, H. J.: American Dental Association Specification No. 12 for Denture Base Resin: Second Revision, J.A.D.A. **46**:54, 1953.
5. Gabel, G. B., and Smith, E. M.: Flow of Methyl Methacrylate, J. D. Res. **22**:237, 1943.
6. Sweeney, W. T., and Schoonover, I. C.: A Progress Report on Denture Base Material, J.A.D.A. **23**:1498, 1936.
7. Skinner, E. W.: The Science of Dental Materials, ed. 4, Philadelphia, 1954, W. B. Saunders Company.
8. Peyton, F. A., and Mann., W. R.: Acrylic and Acrylic-Styrene Resins: Their Properties in Relation to Their Uses as Restorative Materials, J.A.D.A. **29**:1852, 1942.
9. Osborne, John: Investigations Into the Properties of Arcylic Resin Denture Bases, Brit. D. J. **73**:249, 1942.
10. Cornell, J. A., and Coauthors: Tensile Strengths of Modified Polymethyl Methacrylate at Various Rates of Loading, I.A.D.R., Dental Materials Group, March 20, 1955.
11. Cornell, J. A., and Tucker, J. L.: Some Physical Testing of Denture Base Type Materials, I.A.D.R., Dental Materials Group, March 24, 1957.

32ND AND SPRING GARDEN STS.
PHILADELPHIA 4, PA.

## *FIXED PARTIAL DENTURES*

# FACTORS THAT AFFECT THE ACCURACY AND DIMENSIONAL STABILITY OF THE MERCAPTAN RUBBER-BASE IMPRESSION MATERIALS

G. E. MYERS, D.D.S., M.S., F.D.S., AND D. G. STOCKMAN, A.B., D.D.S.
*University of Michigan, School of Dentistry, Ann Arbor, Mich.*

SINCE THEIR INTRODUCTION some 6 years ago, the mercaptan rubber-base (Thiokol polysulfide rubber) impression materials have been steadily improved in physical properties, and refinements in clinical application have been developed. These materials have now established themselves with the agar hydrocolloids as elastic impression materials which are capable of making clinically accurate impressions with excellent reproduction of surface detail, when correctly handled. There are numerous articles in the literature supporting the clinical accuracy of these materials.[1-7] Claims have been made that these materials are very stable and that impressions can be stored for long periods of time before pouring in stone. If an alginate impression, an agar impression, and a rubber-base impression are left exposed on the bench for a few hours, there is no doubt which material is more stable under these conditions. The agar and alginate impressions will show obvious changes in form, while the rubber-base impression appears unaltered. It is possible, however, that dimensional changes not visible to the eye but of clinical significance have occurred in the rubber-base impression during this period. The measurement of such changes is not difficult, although the interpretation of the data obtained in terms of clinical accuracy and clinical procedures is not easy.

### DIMENSIONAL CHANGES

Jorgensen[8] measured the dimensional change of standard specimens of rubber impression materials floating on a mercury bath and drew attention to the part that thermal contraction can play as these materials are cooled from mouth to room temperature. Linear contraction after 24 hours varied with different products from 0.13 to 0.39 per cent, while the thermal contraction averaged 0.23 per cent,

---

This study was supported by the H. H. Rackham Fund of the University of Michigan, project R #432.

from 37° C. to 22° C., for eleven products. Ostlund[9] measured the dimensional change of specimens on a glass plate lubricated with talc. When measured at 24 hours, the linear contraction varied with different products from zero to 0.113 per cent.

Skinner and Cooper[6] emphasized the importance of correct manipulation and technique in the stability of these impression materials and considered them to be more stable than the hydrocolloids. Sturdevant[7] reported that impressions could be stored for days, provided modeling compound was not used to line the tray, while Fairhurst and co-workers[1] found the stability of impressions to be excellent for at least 24 hours. Schnell and Phillips,[10] on the other hand, showed the presence of dimensional changes in impressions after storage for 1 hour and demonstrated that these discrepancies became greater on storage for longer periods. They recommend that impressions be poured as soon as possible.

The objective of this investigation was to evaluate the clinical accuracy and dimensional stability of one mercaptan rubber-base material when a variety of manipulative procedures were employed. By limiting the investigation to one product, variations in handling qualities among products were eliminated, and the available time and effort were used to check the effect of various clinical techniques. Schnell and Phillips[10] found little variation in accuracy and stability among five mercaptan rubber-base materials, and it would seem that the conclusions drawn from a study of one of these products should apply in principle to other similar products. The product used in this study was selected, on the basis of earlier work[3] on the physical properties of these materials, as being suitable for use in inlay, crown, and bridge restorations. Similar series of tests were made on a silicone product, an agar, and an alginate hydrocolloid. In the case of the mercaptan product, the following factors were investigated: influence of variations in mixing time, effect of storing the impression, effect of different types of trays, use of the wash impression technique, and accuracy of a second cast from the same impression.

## METHOD

Impressions of a laboratory model were made (Fig. 1), and the impressions were poured in stone. The accuracy of these stone casts was evaluated by the fit of gold restorations made from direct wax patterns of the laboratory model.

The laboratory model consisted of two ivorine teeth, fixed in a metal base and placed 18 mm. apart. The bicuspid tooth was prepared for a full-crown restoration and the molar tooth was prepared for an MOD restoration. The crown preparation has a shoulder finish, the MOD preparation has no bevels or slices, and both have minimum taper. These modifications from clinical design produced critical preparations which facilitated the detection of small inaccuracies in the impression. A number of full-crown and MOD restorations were waxed directly on these ivorine preparations and cast in hard inlay gold. Two crown and two MOD restorations which would slide snugly on and off the ivorine preparations were selected, and from one pair of restorations a test "bridge" was fabricated (Fig. 1), while the other pair were kept as individual restorations.

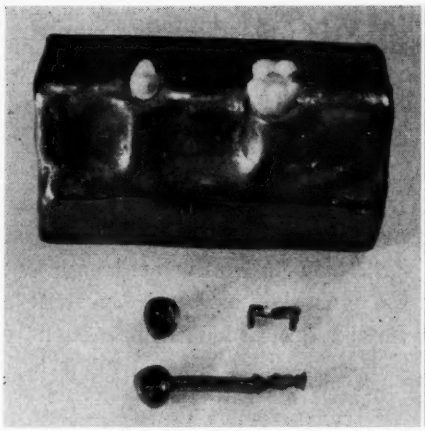


Fig. 1.

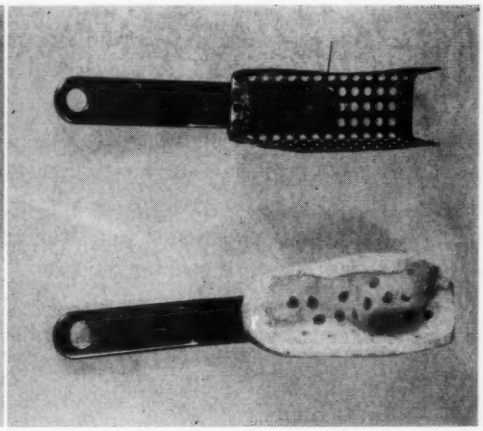


Fig. 2.

Fig. 1.—At the top, the master model with ivorine teeth prepared for a crown and an MOD restoration. Center, separate crown and MOD restorations. Bottom, a test "bridge" made to fit the prepared model.

Fig. 2.—Test trays. Above, a perforated metal, noncontoured tray. Below, a contoured acrylic resin tray.

The base of the laboratory model was immersed in a water bath maintained at 37° C. to simulate mouth-temperature conditions. Preliminary tests showed no difference in the accuracy of impressions left in place on the model for 4 and 6 minutes before removal. However, the longer time was used throughout the investigation. The two types of trays used in the tests are shown in Fig. 2. The impressions were poured in an improved dental stone, hand spatulated for 1 minute using 25 c.c. of water to 100 Gm. of stone. The stone cast was allowed to set one hour before removing it from the impression, and all casts were 24 hours old before being checked for accuracy.

Preliminary studies revealed that reliable and reproducible results could be obtained by the following method of evaluating accuracy. The individual restorations were seated with finger pressure, and if these slid readily to place and seated completely, the model was considered accurate so far as the individual preparations were concerned. Failure to seat completely with finger pressure was considered evidence of inaccuracy. No attempt was made to draw conclusions from the extent of the failure to seat. If both the crown and MOD restorations seated completely, they were removed and the bridge restoration was tried for seating. In this manner each cast was checked for accuracy of a full-crown preparation, an MOD preparation, and a bridge restoration. All casts were checked by the same person, who was not aware of the particular group to which they belonged.

## RESULTS

In recording the results, the casts will be described as accurate or inaccurate, according to whether the test restorations would seat or not. In this context, the words "accurate" and "inaccurate" are intended to mean nothing more than the

results of this test procedure. In many cases, casts which were inaccurate in this test (i.e., the test restorations would not seat) would have produced clinically acceptable restorations.

*Effect of Variations in Mixing Time.*—Skinner[6] showed that undermixing or overmixing produced significant changes in the elastic properties of the rubber-base impression materials to an extent which could influence clinical accuracy. An experienced dentist repeatedly mixing rubber-base impression materials is able to achieve a homogeneous mix free from streaks in about 30 seconds, some 15 seconds less than the manufacturer's recommended time. Ten impressions made with material mixed in 30 seconds were poured immediately in stone and checked for accuracy as described above. A further group of ten impressions was

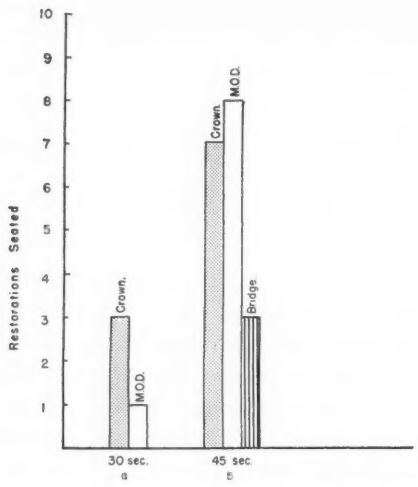



Fig. 3.

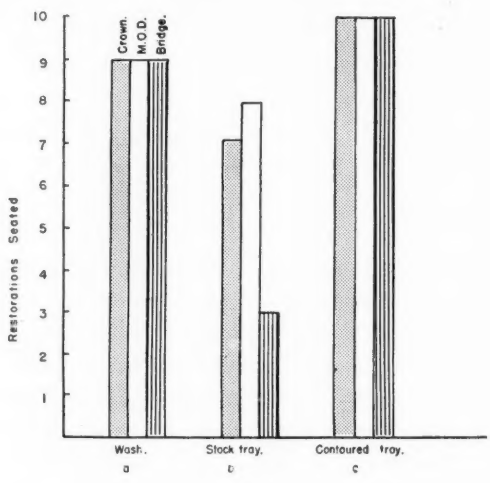



Fig. 4.

Fig. 3.—The effect of mixing time on clinical accuracy. *a*, Undermixed, 30 seconds. *b*, Correct mix, 45 seconds. Ten impressions were in each group.

Fig. 4.—A comparison of the accuracy of three impression techniques. *a*, Wash technique. *b*, Syringe-tray technique with stock tray (perforated metal tray). *c*, Syringe-tray technique with acrylic resin contoured tray. Ten impressions were in each group.

made under identical conditions, but the material was mixed for the recommended period of 45 seconds. The effect of the mixing time on accuracy is seen in Fig. 3. A significantly greater number of casts were accurate in the group for which the material was mixed for 45 seconds. All of these impressions were made using a syringe-tray technique and employing a perforated metal tray not contoured to the mouth tissues. The use of a noncontoured tray is responsible for the failures in the 45-second mix group. The 45-second mixing time was used in all subsequent tests.

*Effect of Tray on Accuracy.*—Ten impressions were made using an acrylic resin contoured tray made with a spacer of two thicknesses of pink baseplate wax, giving approximately 3 mm. thickness of impression material over the entire area. A syringe-tray technique was employed, and all other factors were as

before. In this group, all ten casts were accurate, and the individual restorations and the "bridge" seated completely on all ten casts. (Fig. 4, *c*). These results substantiate the data of other investigators that 3 mm. to 4 mm. thickness of material is more accurate than a large bulk of material. They emphasize, too, the need for a tray to extend down into the edentulous space of fixed partial dentures and maintain the thin layer of impression material in the edentulous area. It can be seen in Fig. 4, *b* (the series in which a noncontoured tray was used) that the seating of the bridge restoration was affected more than the individual restorations.

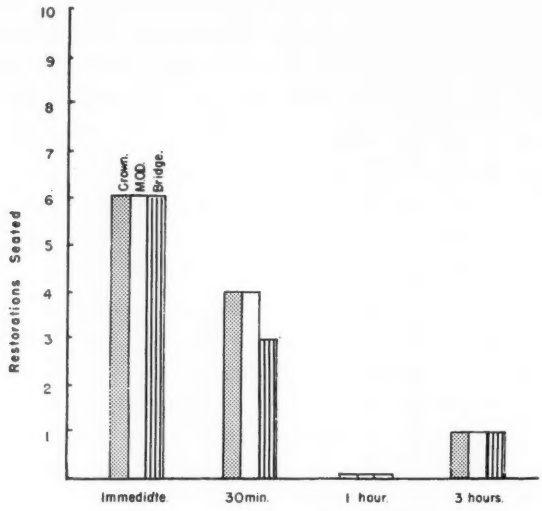
*Accuracy of the Wash Technique.*—Many clinicians are using a technique in which a preliminary impression is made in a stock tray, the impression is removed from the mouth, washed, and dried, and V-shaped spillways are cut from the teeth to the border of the impression. A mix of light-bodied material is then spread over the first impression, and the tray is reseated in the mouth. In this manner, the use of a syringe is eliminated and only one mix of material is made at a time. This technique has been criticized on the grounds that the second mix, the wash, will set under compression and, on removal, the compressed areas will rebound and result in inaccuracies. The V-shaped spillways cut with a sharp scalpel are intended to allow the escape of excess material and prevent compression of the wash material. Ten impressions were made of the master model using this technique and the impressions poured in stone immediately. The crown, MOD, and bridge restorations seated satisfactorily on nine of the ten models, as shown in Fig. 4, *a*.

*The Effect of Storing the Impression.*—Four groups of ten impressions of the master model were made using a syringe-tray technique with a noncontoured metal tray. The first group was poured in stone immediately, the second after 30 minutes, the third after 1 hour, and the fourth group after 3 hours. Those impressions not poured immediately were stored on the bench at room temperature and humidity. The accuracy of the resulting stone casts was checked as described above, and the results are given in Fig. 5. It can be seen that, in general, the longer the impression was stored, the smaller was the number of accurate casts obtained.

Clinical experience does not substantiate that the effect of storage is quite so critical as these data indicate. The nature of the test preparations used must be taken into account. Clinical preparations have more taper, as well as slices and bevels. In addition, in clinical procedures restorations are made on the stone casts and seated in the mouth. In the test procedures the reverse was done—a somewhat more exacting test. To attempt to re-evaluate the above data in terms of clinical practice, four rejected casts were taken at random, one from each of the four groups. Crown and MOD restorations were waxed on these casts and cast in gold. These restorations were then seated on the master model and checked for seating. Clinically acceptable restorations were obtained from three of these four casts. Only those from the cast poured at ½ hour would not seat completely. It should be noted that the tray used in these tests was a noncontoured metal tray, giving a larger bulk of material than would be the case with a contoured acrylic resin tray. The contoured acrylic resin tray should reduce the practical

effect of storage on accuracy. That the ½-hour cast produced unsatisfactory restorations does not indicate that a cast poured at this time will be less accurate than one poured at 1 hour or 3 hours.

Fig. 5.



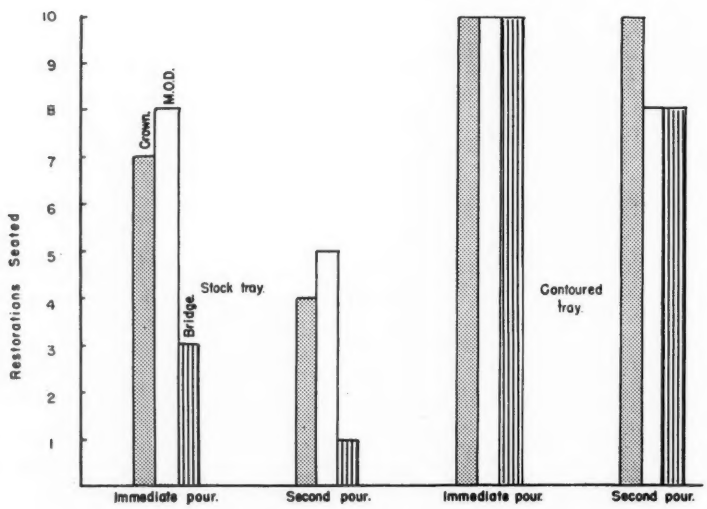




Fig. 6.

Fig. 5.—The effect on clinical accuracy of storing on the bench for varying periods before pouring the cast. Ten impressions were in each group.

Fig. 6.—A comparison of the accuracy of casts made from first and second pours in the same impression. There were two groups of ten impressions, one with the metal or stock tray and the other with the contoured tray.

*Accuracy of a Second Cast From the Same Impression.*—Clinical experience has shown that a second cast can be poured into a rubber-base impression and the accuracy of this second cast, in most cases, is as acceptable as the first.

Two groups of ten impressions were made, one using a syringe-tray technique with a noncontoured tray and the other using a syringe-tray technique and a contoured acrylic resin tray. The impressions were poured immediately in stone, and 1 hour later the cast was removed and the impression was set aside for 10 minutes, when another model was poured. The resulting casts were checked for accuracy, as has been described. The results are seen in Fig. 6.

A greater reduction in accuracy is to be seen in the second-pour casts from the noncontoured trays as compared with those made with contoured trays. The degree of reproducibility in the series using the contoured tray is very good, and for all clinical purposes, the casts from both the first and second pours in this series could be considered equally accurate.

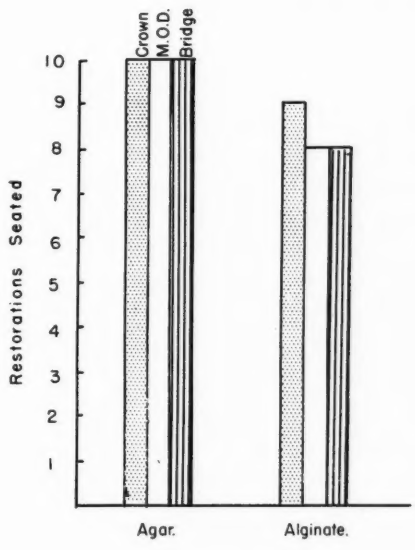



Fig. 7.

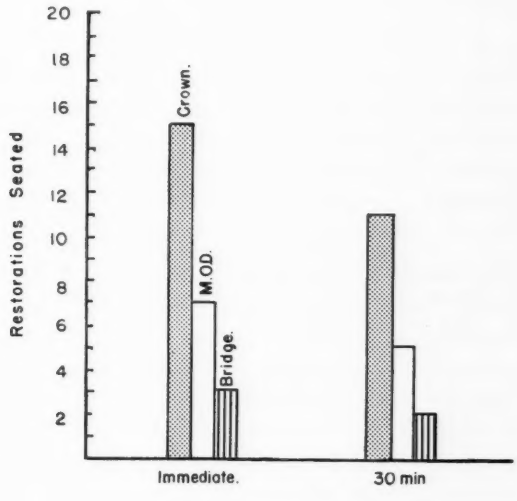



Fig. 8.

Fig. 7.—The accuracy of casts from agar and alginate impressions. Ten impressions were in each group.

Fig. 8.—The accuracy of casts from two groups of twenty impressions made with a silicone product. One group was poured immediately, the other was stored on the bench for 30 minutes.

*Comparison With Agar and Alginate Hydrocolloid Impressions.*—To better assess the clinical significance of the data obtained, two series of impressions were made of the master model using in one series an agar material and in the other series an alginate hydrocolloid material. These were poured in stone immediately, and the stone casts were evaluated as described above. These materials have been in use extensively for many years and their degree of clinical accuracy is well known. Their accuracy in this type of test gives a base line for evaluating the data for the rubber-base materials. The results obtained are shown in Fig. 7. The test restorations seated accurately on all ten of the casts from the agar impressions. The results with the alginate impressions were not quite as good. The

crown seated in nine out of ten of the casts. The MOD and the bridge seated in eight out of ten casts, as shown in Fig. 7. A comparison of the results obtained in the best series of the rubber-base impressions (contoured tray–syringe series, Fig. 4, *c*) with those obtained with the agar material indicates that both these materials are extremely accurate impression materials.

*Comparison With a Silicone Material.*—Two groups of twenty impressions were made with a silicone material using a syringe-tray technique with noncontoured trays. One group was poured in stone immediately, and the other after storing on the bench for 30 minutes. The results obtained on checking the stone casts are seen in Fig. 8. It can be seen that the impressions made with the silicone materials were not as accurate as those made with the comparable mercaptan group (Fig. 4,*b*). The group of impressions stored on the bench for 30 minutes showed a smaller number of accurate casts than the group poured immediately.

## DISCUSSION

A number of points arise in attempting to analyze the results and interpret them in terms of clinical procedures and situations. It must be kept clearly in mind that, in the experimental methods, stone casts were checked by applying prefabricated metal restorations and that the tooth preparations were of the most critical type so far as the fitting of restorations was concerned. This method was designed to detect small dimensional changes and is capable of demonstrating dimensional changes of a considerably smaller degree than could be detected in the normal clinical evaluation of a casting. This was demonstrated, for example, in the series in which four of the rejected casts were used to wax restorations (Fig. 5) and, of the four, three casts produced restorations which were clinically acceptable when tried on the master model. It is felt that the clinical evaluation of a restoration in the mouth is the final test of any restorative procedure and on this basis many of the casts rejected in the tests used in this study would be clinically acceptable. What then is the significance of the variations in the number of stone casts on which the restoration would seat? The variations seen in this study indicate the factors which influence the accuracy of the rubber-base impressions. If unsatisfactory clinical results are being obtained, the data here presented indicate the factors to which attention can be directed to improve the clinical results. The studies indicate some of the requirements for obtaining the maximum degree of accuracy and reproducibility of results from these materials.

Two series of ten impressions in a stock tray were made and poured immediately. One series is recorded in Fig. 5, and the other is recorded in Figs. 3, 4, and 6; a second pour of stone was made in this latter series and the results are recorded in Fig. 6. The difference in values obtained in these two series is typical of the degree of reproducibility of results when a stock tray is used.

*Mixing Time.*—The results show that the use of a shorter mixing time than that recommended by the manufacturers *is* reflected in the accuracy of the impression. Skinner and Cooper[6] showed that both undermixing and overmixing produced significant changes in the elastic properties, and although the effect of mixing for longer than the recommended time was not checked in this study, it seems reasonable to assume from their data and the data obtained in this study

on undermixing that similar inaccuracies may result from overmixing. Accurate timing of the mix to fulfill the manufacturer's directions is desirable.

*The Tray.*—The greater accuracy obtained with the use of a contoured tray which gives a thinner and more uniform layer of impression material substantiates the findings of other investigators. With a material which shrinks over a period of some hours it is obvious that dimensional discrepancies will be greater in large, bulky impressions. Many of the individual restorations seat fully but the bridge will not go into place. The contoured tray which dips into the edentulous space gives a great improvement in the number of casts on which the bridge will seat.

*The Wash Technique.*—The wash technique has been criticized on the basis that the second-mix material will set under compression and will rebound on removal from the mouth. It should be noted that spillways were cut in the first impression from the deepest parts of the prepared teeth to the periphery to act as an outlet for excess material. These impressions were poured immediately. When the wash technique is employed using a stock tray giving a large bulk of material, the effect of storing will be maximal, and it seems desirable to pour this type of impression immediately. Because most of the shrinkage has occurred by the end of 24 hours, [8,9] those who prefer the wash technique might consider making the preliminary impression at a visit previous to that at which the preparations are made. In this way, the preliminary impression can be set aside and will be more stable when it is used to convey the wash. The results obtained in this study indicate that the wash technique is accurate, provided these precautions are taken.

*Storage Time.*—The period of time during which rubber-base impressions can be stored is controversial, and insufficient evidence has been accumulated to produce the final answer. This study substantiates the work of Schnell and Phillips[10] and demonstrates dimensional inaccuracies in casts poured after storing the impression for ½ hour. Longer storage increases the incidence of inaccuracy. However, three out of the four rejected casts selected for further study produced restorations which were clinically acceptable. It seems undesirable at this time to conclude that all rubber-base impressions must be poured immediately. The fact that the elastic qualities and toughness of the material have been shown to improve markedly over the first ½ to 1 hour must be considered.[11] Thin cervical extensions and thin interseptal areas of an impression will be tougher, more elastic, and less susceptible to deformation when pouring the stone if stored for a short time (30 to 60 minutes).

*Second Casts.*—The degree of correlation between the first and second casts from one impression was greater when a contoured tray was used. This is to be expected from the physical properties of the material. When the contoured tray was used with a syringe technique, it was observed that for practical purposes the second cast is as accurate as the first.

*Comparisons of Materials.*—The excellent series of casts obtained with the agar impressions gives a basis for evaluating the clinical significance of the results obtained with the rubber-base material. Agar used in a routine syringe-tray technique gave ten accurate casts out of the series of ten. Only the series using the contoured tray and syringe technique with rubber produced a similar degree

of accuracy. The results with an alginate hydrocolloid were not quite as good as those from the agar hydrocolloid.

The silicone product used was selected as one suitable for a syringe-tray technique and as free from gas production during polymerization. The results obtained were not as satisfactory as those with a comparable polysulfide rubber material under similar conditions. Reproduction of the MOD preparation and the bridges was not satisfactory in a greater proportion of cases with the silicone than with the mercaptan rubber-base material. However, it is unlikely that this difference would be detectable in clinical use.

## CONCLUSIONS

In presenting the conclusions, the term "accurate" cast refers to a cast on which the test restorations would seat. Some of the casts rejected by this test were shown to be clinically accurate.

1. The mixing time of the mercaptan rubber-base impression materials is critical and the manufacturer's recommended time should be used. Undermixing produced a significant decrease in the number of accurate casts.

2. A contoured tray leaving a space of approximately 3 mm. between the tray and the tissues gave a greater number of accurate casts than a stock tray when using the syringe-tray technique. This is especially true where an edentulous space for a bridge is involved.

3. The wash technique gave accurate casts when adequate spillways were used to prevent the wash material from setting under compression.

4. Storing an impression on the bench produced dimensional changes in a number of the casts after ½ hour. Storage for longer periods increased the number of inaccurate casts. Three out of four casts rejected as inaccurate by the testing method used, however, gave clinically satisfactory restorations.

5. The number of accurate casts from a second pour in the same impression was higher when a contoured tray was used than when a stock tray was used.

6. Impressions taken with an agar impression material and evaluated in the same manner as the rubber-base impression gave ten out of ten acceptable casts. Impressions with an alginate product gave eight out of ten accurate casts.

7. The number of accurate casts obtained from a series of silicone impressions was not as great as that obtained with a comparable mercaptan rubber under similar conditions. It is unlikely that the difference would be detectable in the normal clinical use of these products.

8. The data presented indicate some of the factors which influence the results obtained with the rubber-base products. If unsatisfactory clinical results are obtained, an analysis of the technique in use, in the light of factors discussed in this article, may pinpoint the source of error.

## REFERENCES

1. Fairhurst, C. W., Furman, T. C., Schallhorn, R. V., Kirkpatrick, E. L., and Ryge, G: Elastic Properties of Rubber Base Impression Materials, J. Pros. Den. **6**:534-542, 1956.

2. Kinghorn, A., and Allan, D. N.: Inlay Production From Rubber Based Impressions, Brit. D. J. **103**:1-6, 1957.
3. Myers, G. E., Wepfer, G. G., and Peyton, F. A.: The Thiokol Rubber Base Impression Materials, J. Pros. Den. **8**:330-339, 1958.
4. Pearson, S. L.: New Elastic Impression Material, Brit. D. J. **99**:72-76, 1955.
5. Rosensteil, E.: Rubber Base Elastic Impression Material, Brit. D. J. **98**:392-394, 1955.
6. Skinner, E. W., and Cooper, E. N.: Desirable Properties and Use of Rubber Impression Materials, J.A.D.A. **51**:523-536, 1955.
7. Sturdevant, C. M.: Impressions for Indirect Inlays, J.A.D.A. **54**:357-366, 1957.
8. Jorgensen, K. D.: Thiokol as a Dental Impression Material, Acta odont. scandinav. **14**:313-330, 1957.
9. Ostlund, S. G.: Some Properties of Rubber Base Materials, Odont. tskr. **65**:94-104, 1957.
10. Schnell, R. J., and Phillips, R. W.: Dimensional Stability of Rubber Base Impressions and Certain Other Factors Affecting Accuracy, J.A.D.A. **57**:39-48, 1958.
11. Hansen, W. C., and Miller, W. A. C.: Specification for Rubber Base Impression Material, Dental Materials Group, International Association for Dental Research, Atlantic City, March, 1957.

University of Michigan
School of Dentistry
Ann Arbor, Mich.

# THE FORCES THAT OPPOSE THE WITHDRAWAL OF IMPRESSIONS

DIORACY FONTERRADA VIEIRA, C.D.*
*São Paulo, Brazil*

THE LITTLE KNOWLEDGE dentists have of the forces that act on dental materials constitutes a great limitation to the success of their work. This limitation is due, perhaps, to the biologic conditions inherent in all dental work.

The forces that oppose the withdrawal of impressions are an example of this fact. Although it is practically impossible to determine exactly the magnitude of these forces, it is possible to form an idea of the external and internal forces involved and the possible influence of these forces upon impression materials.

## RETENTIVE FORCES IN THE WITHDRAWAL OF IMPRESSIONS

An impression material solidifies on contact at the moment the impression is made. On withdrawal, two types of forces act upon the material: (1) *external forces,* applied by the dentist on removal, and (2) *forces which oppose this withdrawal.* These latter forces may be intrinsic or extrinsic.

The reaction of the material to the forces applied in withdrawal represents the intrinsic forces. These forces are the *stress* of the material, which acts to maintain the form and dimension of the impression.

The forces which oppose the withdrawal of the impression and which are independent of impression material represent the extrinsic forces. These forces are (1) inclined surfaces situated between the "equatorial line" and the anatomic neck of the tooth, (2) friction between the surfaces to be impressed and the hardened impression, (3) the action of gravity, (4) contraction of the material, which may occur in hardening, and (5) forces which aid retention and stability of complete dentures, such as atmospheric pressure, adhesion on contact, surface tension, etc.

The manner in which these different extrinsic forces act upon the impression material and influence the hardened impression can be observed. Such an analysis has great importance in evaluating the resistance of the impression material.

Let us consider that an impression of a single tooth is being removed. A rigid metal ring has been used as a tray (Fig. 1). The external forces applied by the dentist on the sides of the ring are transmitted to the elementary units (molecules, atoms, or micelles) of the material and break up into innumerable smaller forces.

*Docente-Livre and assistant of Applied Metallurgy and Chemistry from the Faculty of Pharmacy and Odontology, University of São Paulo.

If the extrinsic forces which oppose the withdrawal of the impression did not exist, the impression would be removed through a force resulting from those forces applied by the dentist. However, the problem is much more complex. Let us analyze these forces that oppose the withdrawal of impressions.

## INCLINED PLANES

Retentive surfaces of teeth are those surfaces which are limited by the equatorial line and the anatomic neck of the tooth. These surfaces function as inclined planes, for a minute and determined area of the surface of the tooth is a plane. This plane is inclined at a certain angle to the long axis of the tooth and is an obstacle to free movement of the impression material in the withdrawal of the impression.

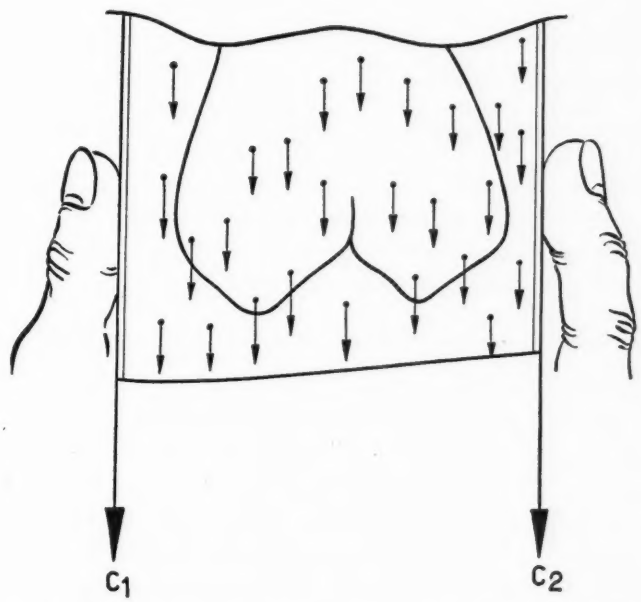



Fig. 1.—A single impression is withdrawn from a tooth. The forces ($C_1$ and $C_2$) applied by the fingers break up into numerous other forces, all of which act on the impression material.

By placing a solid on an inclined plane, we can study the conditions that permit stabilization or movement of the solid (Fig. 2). Let $P$ be the force that represents the weight of the body. This force is broken up on the inclined plane into two other forces. One normal force $(N)$ on the surface of the plane keeps the body fixed. The other force $(R)$ tends to move the body in the direction of the inclined plane $(AB)$. This movement is possible only when force $R$ is larger than force $M$, which is friction. Even though friction $(M)$ is nonexistent, force $R$, which moves the body, is always smaller in magnitude than $P$.

Let us apply this principle to an impression material that has hardened and is being removed (Fig. 3). We saw that the external forces ($C_1$ and $C_2$) applied

by the dentist break up into numerous other forces. Let one of these be force $P$ which acts upon a point $(A)$ of the impression material. Point $A$ is in contact with an inclined plane, represented by a tangent $(CB)$ to $A$. Force $P$ breaks up into equal parts ($N$ and $R$). Force $N$ is perpendicular to the surface at $A$ and is neutralized by the resistance of the tooth, represented by force $Q$, which acts on

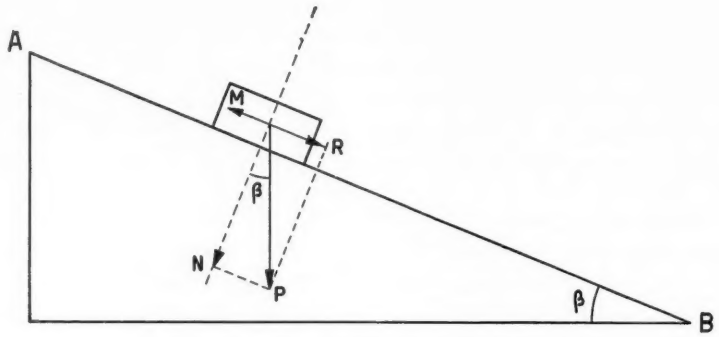



Fig. 2.—The movement of a solid on an inclined plane is controlled by opposing forces.

the same line but in the opposite direction. Therefore, force $R$, which moves the body in its downward path on the inclined plane, is smaller than force $P$, applied to dislocate it. Force $R$ also must overcome the opposing resistance provoked by friction, a factor which diminishes yet further force $R$.

We can estimate the magnitude of force $R$, because $\cos \alpha = \frac{R}{P}$; therefore, $R = P \cos \alpha$. From this relationship, if angle $\alpha$ is enlarged, and this happens with an increase in the inclination of the tooth crown at point $A$, $\cos \alpha$ diminishes. In diminishing $\cos \alpha$ and at the same time maintaining the dislocating force $R$ at the same magnitude, it is necessary to increase force $P$, which means an increase in forces $C_1$ and $C_2$. The explanation is that since tooth crowns are more inclined between the equatorial line and the neck, the force applied in removal of the impression must be greater. The greater the number of teeth, the greater is the quantity of impression material subject to the action of the respective inclined planes and the greater must be the external force applied to remove the impression.

## FRICTION

Friction between the surfaces in contact, that is, between the impression and the tooth, is an opposing element in the removal of an impression.

An inclined plane forms with the horizontal plane a certain angle $(\beta)$ which influences the magnitude of friction. The progressive increase of angle $\beta$ causes a simultaneous decrease in friction up to the point where friction no more exists, that is, when $\beta$ is an angle of 90 degrees. This condition is true only for the inclined plane situation in Fig. 2. Actually, when the retentive surfaces of the tooth are considered as a series of inclined planes, friction exists even when a retentive surface forms an angle of 90 degrees with the horizontal plane. This is true because

of the action of the compressing forces which maintain the impression material in contact with the tooth (contraction, for example). Conversely, as the angle is diminished, friction is increased to a point where force $R$ is neutralized by force $M$.

Thus, the removal of the impression is also made difficult by friction. The friction is greater when the inclination of the tooth between the equatorial line and the anatomic neck is smaller in relation to the horizontal plane because the angle formed between the inclined plane and the horizontal plane is smaller. In Fig. 4, $AB$ is an inclined plane between the equatorial line and the anatomic neck and is tangent to the proximal surface of the tooth where it meets the horizontal plane $(EF)$. $CD$ is the plane that crosses the larger axis of the tooth. If $\delta$ is constant, when we increase $\gamma$ (the inclination of plane $AB$ in relation to the larger axis of the tooth) the angle $\beta$ will diminish, with a consquent increase of friction upon plane $AB$. If we increase friction, force $R$ (Fig. 3), which is necessary for moving the body, will diminish, thus making withdrawal of the impression material difficult due to other forces, such as contraction of the material, etc.

The coefficient of friction between two surfaces varies according to the nature of the bodies in contact, the existence or absence of special lubricating fluids, etc.

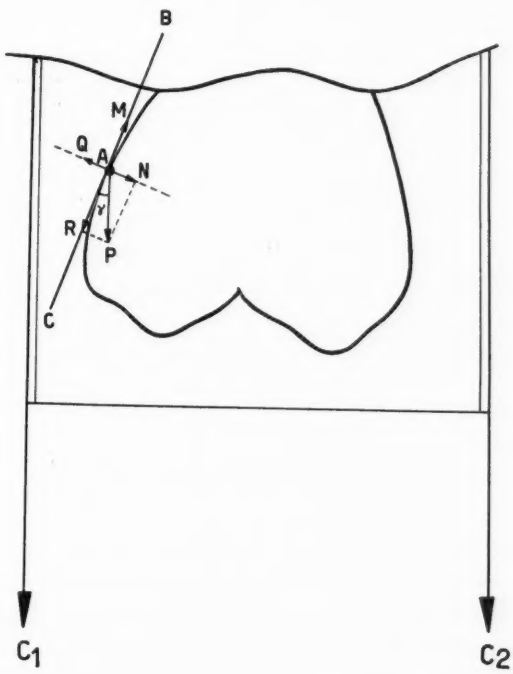



Fig. 3.—The forces involved in the removal of a hardened impression material from a tooth.

There are some materials whose coefficient of friction with tooth substance is greater than others, e.g., impression modeling compound or impression plaster. Other materials, although highly sticky before hardening, do not conserve their

stickiness when hardened; their surfaces becomes very smooth. These materials have a low coefficient of friction in relation to the enamel or dentine (hydrocolloids, rubber-base materials, etc.).

The existence of lubricating fluids between the surfaces that rub against each other diminishes friction to a great extent, thus facilitating removal of the impression. In larger impressions with impression modeling compounds, saliva is a lubricating fluid. When individual impressions of cavities are made with impression modeling compounds, special fluids are used.

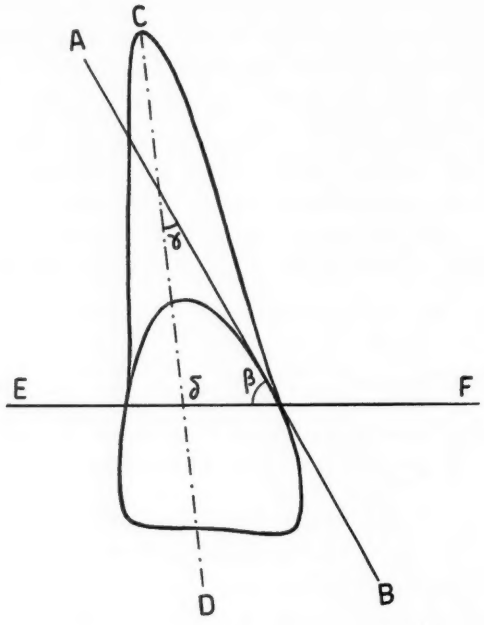



Fig. 4.—Friction influences the removal of the impression. The friction increases when the inclination of the tooth between the equatorial line and the anatomic neck is small.

OTHER FORCES

*Gravity.*—Gravity affects mandibular impressions and is in addition to the forces described.

*Contraction.*—Contraction during the hardening of the impression material causes the material to be compressed against the tooth surface. Thus the removal of the impression is resisted because of the compression force of the impression material (*N*, Fig. 3). Impression modeling compounds have such contraction.

*Atmospheric Pressure, Adhesion, and Surface Tension.*—Atmospheric pressure, adhesion from contact, and surface tension are forces that obstruct the easy re-removal of impressions. There is with hydrocolloids, for example, the necessity to break the border seal, the contact adhesion, and the surface tension of saliva with a light movement of the lips or of the tray in order to remove the impression more easily.

## INFLUENCE OF FORCES ON IMPRESSION MATERIALS

External forces acting upon an impression material provoke an internal reaction which is called *stress*. When the magnitude of the applied external force is superior to stress, three consequences can be observed in the material: (1) elastic strains which disappear when the external loads cease, (2) permanent strains or distortions, and (3) fracture of the material.

Stresses provoked in the impression material by the external load applied on removal of the impression are very complex. There are various actions taking place simultaneously, such as traction stress, compression stress, and shearing stress.

*Traction Stress.*—Upon removal of a ring filled with impression material (Fig. 5), the material at point $B$ (between the equatorial line and the apex of the cusps) suffers no opposition and thus is free for a movement proportional to component $P$ of $C_1$ and $C_2$. However, the material at $A$ suffers the action of component $P'$ which is equal to $P$ but with behavior that differs. At point $A$, component $P'$ breaks up, partly to form force $R$, which moves the material at $A$. To facilitate the analysis, $P$ and $P'$ have such magnitudes that the resulting component $(R)$ is neutralized by friction $(M)$. Since this does not happen at $B$, the impression material there will be moved by action of $P$. The material at $A$, however, remains static and, as a consequence, an external traction load $(P)$ acts between $A$ and $B$ and produces traction stress in the material.

At points $A$ and $E$, forces also act in different directions. These forces tend to remove $A$ and $E$ in the same way as $A$ and $B$.

*Compression Stress.*—On removal of the impression, the material against the gums (between $F$ and $D$, Fig. 5) is compressed when passing through a smaller space (between $C$ and $B$) because of the rigid ring. Thus, compression stresses are induced in the material.

*Shearing Stress.*—The material situated in the proximity of the ring or the tray is locked to the tray by adhesion (impression compound) or by mechanical retention (hydrocolloids, etc.). This material is forced, with no opposition, in the direction of $C_1$ and $C_2$ (Fig. 1). The tray moves in the same direction while the extrinsic forces impede a movement of the same intensity in the impression material in contact with the tooth.

If the external removing forces $(C_1$ and $C_2)$ are such that their various components cannot overcome friction and other opposing forces, the material in contact with the tray moves in the direction of $C_1$ and $C_2$. This causes these forces to function as tangential loads, thus inducing shearing stresses in the material. These loads may bring either distortions or fractures of the material on removal if the material is not sufficiently flexible.

The force applied by the dentist when removing the impression is distributed over all the material. Therefore, each molecule, crystal, or micelle is forced in the same direction by various components of the applied force (Fig. 6).

Let one of the components of forces $C_1$ and $C_2$ be $P$, which acts upon area $S$. Let the quotient $\frac{P}{S}$ be the load applied. Should this quotient be superior to the

resistance of the impression material, the following will take place: (1) fracture of impression material during removal if it is rigid, (2) permanent distortion of the impression material if it is plastic, or (3) elastic distortion of the impression material if it is flexible.

## INFLUENCE OF MATERIALS ON IMPRESSIONS

The properties of the material influence the accuracy of the impression. If the material is elastic, the impression may be correct. If the material is plastic, the impression may be distorted. If the material is rigid, the impression may fracture.

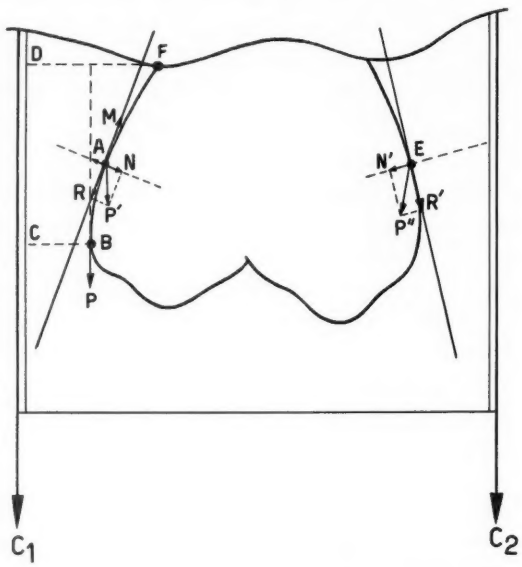



Fig. 5.—Traction, shearing, and compression stresses are introduced upon removal of the impression.

## IMPRESSIONS OF CAVITY PREPARATIONS

Different impression materials are used for varying types of cavity preparations.

*Inelastic Impression Materials.*—Inelastic impression materials include such materials as impression modeling compound. A ring or board is trimmed so that it extends beyond the equatorial line in the direction of the gum, but only toward that portion corresponding to the gum extension of the cavity. This measure prevents the impression material from being carried into the retentive zone. Impression material in the retentive zone causes fractures or distortions upon removal, and the removal itself may be impeded. The removal is easier when the proximal extension of the preparation has the form of a slice rather than that of a box preparation.

*Elastic Impression Materials.*—Elastic impression material is removed easily even when the cavity preparation, through some defect, is retentive. When the preparation is retentive, the defect is perceived when the wax pattern is made on the die.

### CAVITY PREPARATIONS

Cavity preparations with converging walls should be avoided for obvious reasons. The inelastic impression materials are distorted or fractured, and the elastic materials hide defects which are discovered only later.

Cavity preparations with diverging walls are called expulsive cavities. They prevent the retentive effect of dovetailing and prevent irregularities of the cavity walls and of the impression material. Impressions are easier with these preparations.

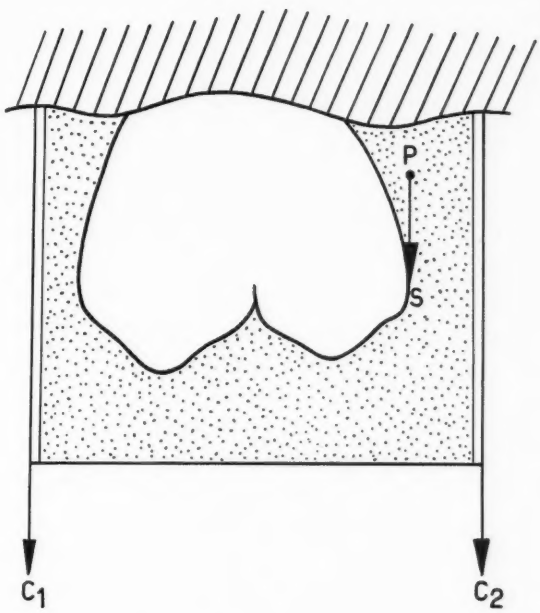



**Fig. 6.—All molecules of the impression material are forced in the same direction by the components of the force applied by the dentist during removal of the impression.**

The impressions of cavity preparations with parallel walls can be made with either elastic or inelastic material. Lubricants must be used because friction is greater due to rugosity of cavity walls which are apparently smooth. The rigid impression material extends into all the irregularities and cannot be removed without fracturing or distortion.

### IMPRESSIONS COVERING EXTENSIVE AREAS

Forces in opposition to removal of impressions covering large areas are great in number and magnitude. Thus, elasticity sufficient to resist these forces is necessary.

Before the advent of hydrocolloids, the impression of retentive surfaces was made in sections (modeling compound) or the impression was fractured carefully before removal (impression plaster). The hydrocolloids have made it possible to

make impressions of retentive surfaces with considerable ease. However, the elasticity of hydrocolloid is not always great enough to resist the opposing forces, especially when the forces are of great magnitude and the volume of the material is small. This is the reason for frequent fractures of hydrocolloid impressions in proximal regions or in the small spaces between the teeth.

The distortion that occurs from external removal forces that are greater than the elastic limit of the material may be of great magnitude. The elasticity of impression materials is variable and not always controllable. Only those materials that are sufficiently elastic, according to a minimum or standard such as specification No. 11 of the American Dental Association, should be used.

Rua Três Rios, 363
São Paulo, Brasil

# A DIRECT-INDIRECT TECHNIQUE FOR INDIVIDUAL GOLD CROWNS

FRANK N. ELLIS, COMMANDER (DC) USN
*San Diego, Calif.*

THE FULL GOLD CROWN is the restoration of choice for all severely damaged posterior teeth. It restores the function, contour, strength, and durability of the tooth and serves to maintain the vertical dimension of occlusion.

For esthetic reasons, gold crowns replacing upper bicuspids and first molars and lower bicuspids should be made with a veneer of plastic on the buccal surface. A gold occlusal surface may flatter the appearance of the mouth, but a gold buccal surface is always unsightly. The veneer does not weaken or compromise any of the virtues of gold crowns. It is not subject to excessive wear, and it is easy to fabricate if acrylic resins are used. The construction of the veneer crown is no problem for the dentist who has access to the services of a skilled gold technician experienced in crown and fixed partial denture techniques. The technique described is for the benefit of the dentist who does not have this type of assistance available, but who finds the construction of gold crowns an essential part of operative dentistry.

The laboratory work is minimal and, with the exception of carving and investing, can be done by any properly instructed laboratory technician. This method requires only a minimum of chair time, no casts, and only one die.

## PREPARATION

The crown preparation should be adapted to the condition of the tooth. Care is taken to preserve as much of the tooth structure as possible, but all weakened or undermined portions of enamel which might break are removed (Figs. 1 and 2).

A continuous, definite finish line must surround the tooth at a position well below the free gingival margin, especially on the buccal aspect of upper bicuspids where the gold margin would be most apparent. To prepare a tooth so the position of the finish line is in doubt is slipshod workmanship. It will make impossible the construction of a crown margin which can be finished properly. A "raised" margin (with reference to the surface of the tooth) is an irritating margin, and chronic inflammation of the gingival tissue will result. Care in the preparation for the crown will improve the final results. Cautious removal of the enamel and the use of grooves for strength will provide a more rugged restoration. Too many teeth are prepared so they resemble upside down ice cream cones with the tips sliced off.

Fig. 1.

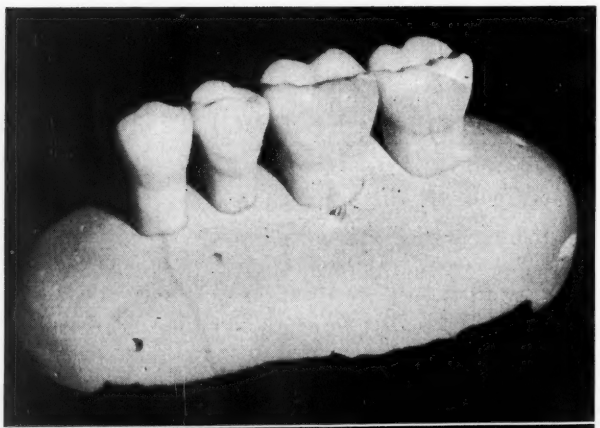


Fig. 2.

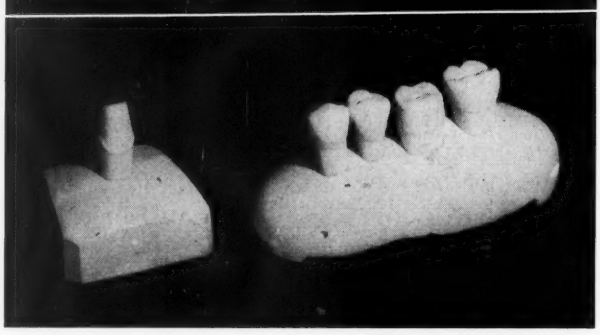


Fig. 1.—Lower teeth before preparation.
Fig. 2.—A central incisor and first molar prepared for full veneer crowns.

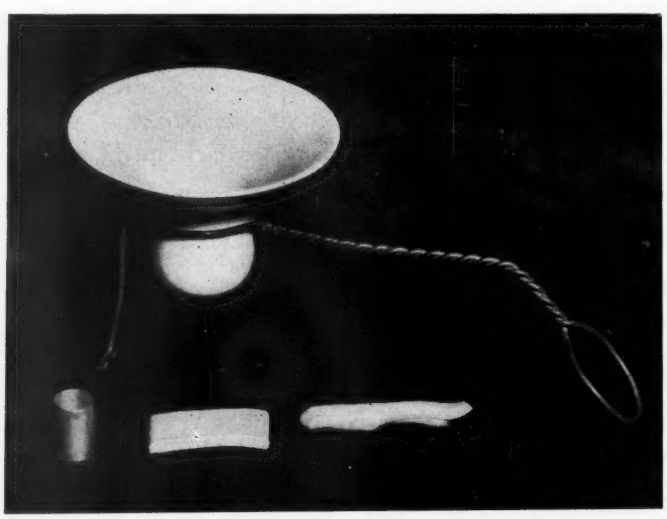


Fig. 3.—A porcelain casserole is used to heat Dietrich's impression material. Below are shown the copper band and impression material before and after molding.

IMPRESSION FOR THE DIE

In this technique, the final result is limited in its accuracy by the accuracy of the reproduction of the prepared tooth in the die. *A precisely accurate die is vital.* There are several acceptable methods of impression making, any one of which will ensure an accurate die. I prefer the Thompson hydrocolloid technique. This is

Fig. 4.

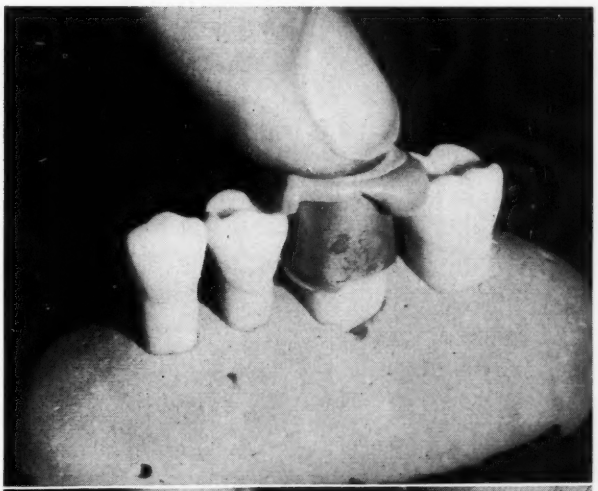


Fig. 5.

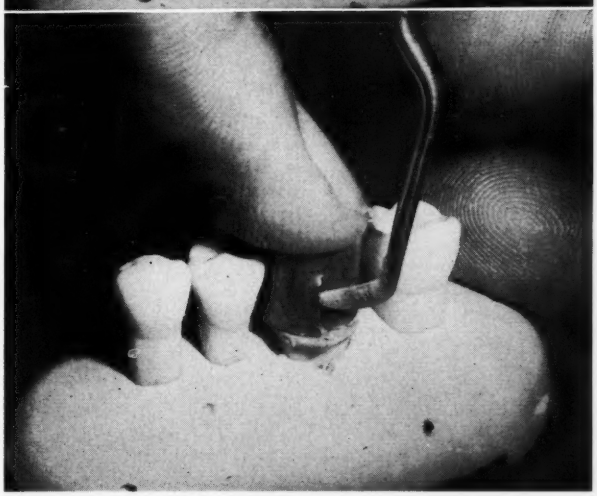


Fig. 4.—The copper band filled with Dietrich's impression material is carried into place with firm finger pressure.
Fig. 5.—With a gold knife the copper band is split for removal.

the method of choice in any office which is equipped with a tempering unit, the proper trays, and a trained assistant. However, there are other methods of achieving the same result. Silicone rubber impression materials and various impression waxes have been used successfully. When the equipment and assistance necessary

for the use of the hydrocolloid technique are not available, I use Dietrich's elastic inlay impression material. This material will give a high degree of accuracy when it is handled with care. The directions must be followed precisely, because otherwise inaccuracies are sure to result. These inaccuracies will not be apparent until the crown is finished and an attempt is made to fit it to the tooth.

### USE OF DIETRICH'S IMPRESSION MATERIAL

A copper band (about one band size too large) is festooned to the prepared tooth so that it fits loosely. The band is heated to cherry redness and quenched in alcohol. This serves to clean, soften, and thin the band (Fig. 3). A 1-inch portion of Dietrich's impression material is boiled in a small porcelain casserole (this can be done over the small flame on the bracket table). The softened material is removed and fashioned quickly into a roll. It is reheated in water for a moment longer and then pushed into the copper band which is at once forced into place over the preparation.

Success will be attained only if great finger pressure is used in carrying the confined impression material onto the tooth. If the band is of the proper size and properly adapted and if the material is carried to the preparation at the right temperature with sufficient force, a beautiful impression complete in every detail will result (Fig. 4).

Finger pressure is held on the impression material while it is chilled with cold water for 2 minutes. The chilling is continued for another 3 minutes with the pressure removed. The band is removed by cutting the soft metal with a gold knife, beginning with the point of the knife at the gingival edge and slicing through it occlusally while stabilizing the band and impression with a finger (Fig. 5). The cut band is peeled from the impression and discarded. The impression is removed

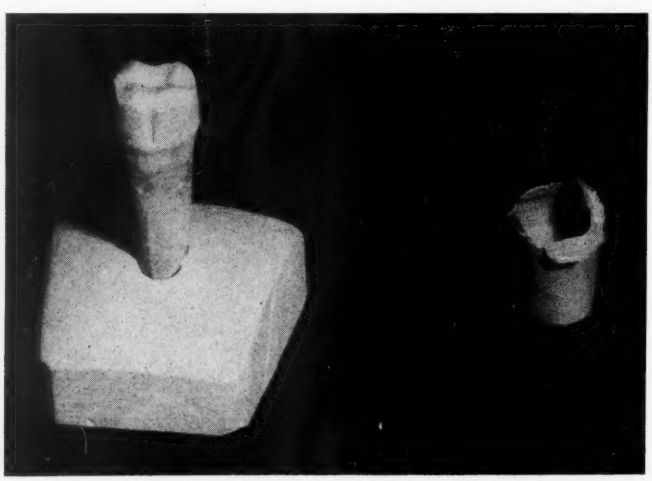


**Fig. 6.—The die and an impression. Note the flaw in the impression which resulted from an improperly fitted copper band.**

from the tooth with one quick, careful motion. A die stone is poured into the impression to form the die. This must not be disturbed until the stone has set thoroughly hard (Fig. 6).

INTEROCCLUSAL RECORD

A 1-inch piece of inlay wax is softened over a flame and molded into a ball with the fingers. One side is flamed slightly, then pressed firmly against the prepared tooth; a finger is held on each side of the tooth so that the wax will be pressed against the preparation. The fingers are removed quickly, and the patient is directed to close the teeth into centric occlusal contact. If this is done in proper sequence, a well-condensed wax interocclusal record with accurate occlusal markings will be obtained (Fig. 7). A warmed Hollenback No. 3 instrument is used to contour

Fig. 7.

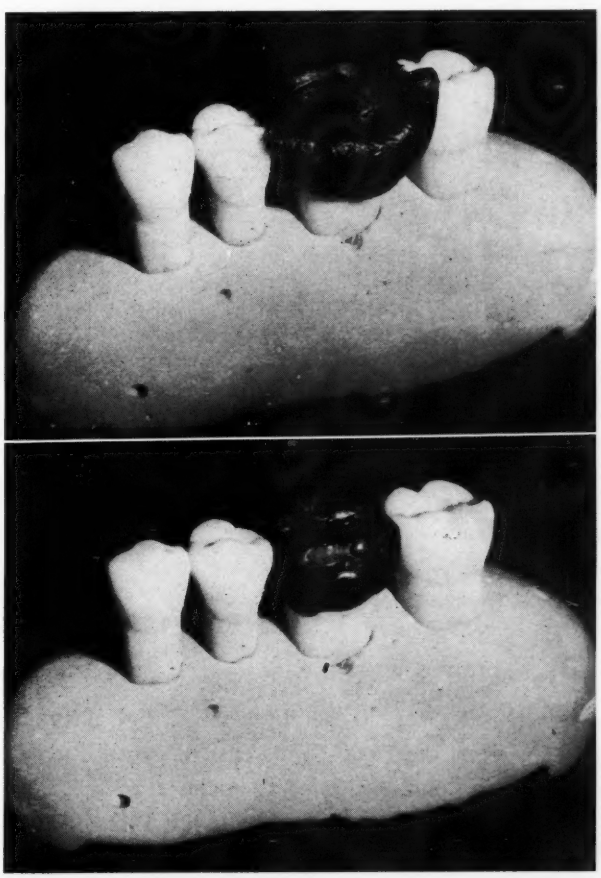


Fig. 8.

Fig. 7.—The wax interocclusal record shows the occlusal markings of the opposing teeth.
Fig. 8.—The wax pattern is carved to its rough form in the mouth. Note the perfected contact areas.

the wax to the desired shape of the finished crown. The wax interocclusal record can be removed from time to time to aid in this procedure (Fig. 8).

A temporary aluminum crown is placed on the tooth with zinc oxide and eugenol cement. The shade of the tooth is determined and the patient is dismissed.

### LABORATORY PROCEDURE

The impression is removed from the die by immersing in boiling water until it is soft enough to be pulled away. The die is trimmed so that the finish line is prominent and easily accessible. The die may be soaked in oil to fill the pores of the stone if desired. It should be well saturated with Microfilm.

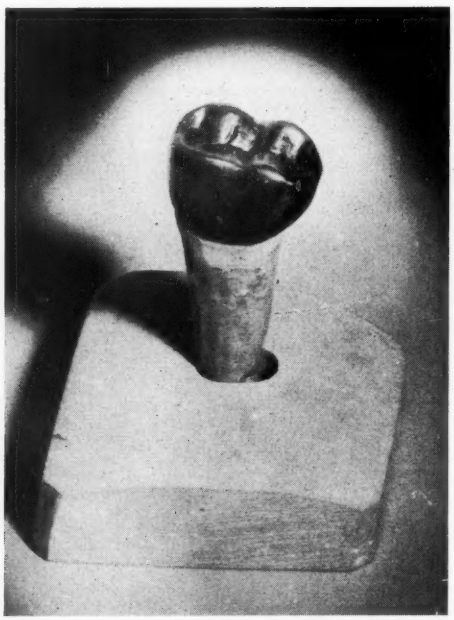


Fig. 9.—The wax pattern is finished on the die.

### FORMING THE WAX PATTERN

The wax interocclusal record is slowly warmed high above a flame, with care being taken not to glaze any portion of it. Then it is gently forced into place on the die. It should be removed once or twice to make sure that no particles of wax are trapped underneath it. Accurate seating at this time is critical. The die and wax are held closely together with a thumb and forefinger, while a hot instrument is used to soften the wax on each proximal surface. As it is softened, the wax is forced into place with finger pressure. Careful contouring around the finish line is necessary, and a slight thickening of the wax in this area will give the crown added strength and provide a dependable gold margin.

The occlusal surface is carved with appropriate instruments. If the occlusal surface markings are to be copied, this should be done with a natural tooth as a guide. Carving charts or simple sketches of anatomy found in textbooks are inadequate.

The wax pattern is polished with a heated pledget of wet cotton, then with a piece of silk. The finish line should be carefully rechecked and readapted where necessary. The wax must be carried exactly to the finish line—no farther and no less (Fig. 9).

### FORMING THE WINDOW FOR THE VENEER

When the pattern is finished and polished, and not before, the window in the buccal surface for the veneer is cut out. This is done with a slightly warmed hoe, and undercuts are made with an angle former. Care and experience are required

Fig. 10.—The finished crowns with the veneers in place.

before this becomes an easy procedure. The retention of the acrylic resin veneer will be satisfactory if a continuous undercut is made all around the window. This makes a "jewelers' joint." Other methods for producing retention may be used provided they are adequate.

Upon completion of the window, the pattern is carefully rechecked, sprued, and cast in a hard gold. The casting is cleaned and then, before trying it back on the die, it is placed in a "stripper"* for 10 to 15 seconds to remove a layer of gold from the inner surface of the crown by electrolytic action. The margins are protected from the electrolytic action of the stripper by coating them with fingernail polish. The crown should now slip into place on the die with very little effort. The sprue is removed and the casting is polished.

The acrylic resin veneer is applied to the otherwise finished crown. If desired, the patient may be recalled so the crown can be fitted and the occlusion checked

*Englehardt Gold Stripper.

before the wax pattern for the window is waxed in the mouth. This is not essential, however, since the veneer can be waxed with the crown on the die if skill and judgment are used. When the wax-up is satisfactory, the crown is invested in a small flask and acrylic resin of the selected color is applied. A crosslinked monomer is used with one of the standard acrylic resin polymers. The resulting veneer will be harder than if an ordinary monomer is used. For the best results, the resin should be cured overnight at 160° F.

When polished and cemented into place, the veneer crown makes a remarkably lifelike restoration (Fig. 10). A crown of this type approaches the ideal of operative dentistry. It preserves the remaining portion of the tooth, it restores function, it maintains the vertical dimension of occlusion, and it has a good appearance.

SUMMARY

A direct-indirect technique for constructing a gold crown with an acrylic resin veneer facing has been described. It is a simple technique which can be accomplished with a minimum of chair and laboratory time. Only one impression and one die are required. Casts are unnecessary. The restoration provides satisfaction in durability, restored function, and esthetic appearance.

770 Loma Valley Rd.
San Diego 6, Calif.

# WHY DENTAL RESTORATIONS SHOULD HAVE CUSPS

CHARLES E. STUART, D.D.S.
*Ventura, Calif.*

THE MOST IMPORTANT PHASE of dental treatment is the restoration of the dentition to its best possible form and best health with a minimum of violence. We must remove from the oral organ all factors that are injuring it and return to it those relationships which are more healthful. If the patient has periodontitis, we must remove the excitative causes and any predisposing causes. If the oral organ has lost some of its tools and supports, we must replace them without causing this semivoluntary organ to make new accommodations and adaptations. The treatment must leave the mouth in the best biomechanical condition possible.

## RELATIONSHIP OF CUSPS AND THE CONDYLES

I have been compelled by experiences and experiments to conclude that the mouth is maintained in the best condition by relating cusps and condyles so that neither one nor the other becomes a tyrant. They should be cooperant. Furthermore, I regard a tooth without cusps to be as crippled as a leg without a foot. Of course, a person can live without either feet or cusps, but he would not choose to do so if he could prevent it.

I value the oral organ so highly that I have disciplined myself to subscribe cheerfully to the accuracy that is required to restore cusps to teeth. I take the greatest pains to treat my patients' teeth so that they may be kept in function throughout life. I have adopted cusps because I do not know how to restore occlusion, organize it, make it useful, guarantee its harmlessness, or relate the anterior teeth to the molars and bicuspids without cusps. Cusps need to be properly placed in the interarch space and must be properly graded in heights and sizes to be in harmony with the movements of the mandible. Cusps are the basic units of most of the occlusion. They have to be properly related to their opponents and to the jaw motions to be units of organized occlusion.

## PRESENCE OF CUSPS

In people past 60 years of age, I have found the mouths in best condition to be those which have had such cuspal organizations that the cusps are still almost

---

Read before the Greater New York Academy of Prosthodontics meeting, the Greater New York Dental meeting, the American Denture Society, the American Academy of Crown and Bridge Prosthodontics, the American Academy of Restorative Dentistry, and the Chicago Dental Society meetings.

intact. The periodontiums are well preserved and the intercuspations are in centric relation. These teeth would have had no cusps at all at advanced ages had there been a jaw-guiding malocclusion. I have not found in the living any dentition that has benefited from excessive wear. Very few of the worn dentitions that I have occasion to treat have exceptionally good periodontiums. How or why collected Eskimos' skulls have had such dense alveolar bone I cannot explain, except perhaps that the teeth were prematurely worn in people who died before reaching old age.

## RESTORATION OF CUSPS

To restore cusps, the dentist must examine carefully all factors related to cuspal organization. These essential factors must be ascertained: (1) the most posterior position of the opening-closing axis of the mandible, (2) the slant and the character of each lateral condyle path, (3) the amount, the commencement, and the direction of the side shift of the mandible, (4) the protrusive paths of the condyles, (5) the slant of the occlusal plane and the curvature of Spee's curves, and (6) other odontocondylar relations.

Such data must be recorded uncompromisingly precisely in an instrument upon which accurate casts have been mounted, so that a correct diagnosis can be made. The teeth must be prepared with due regard to the position, heights, and sizes of the cusps. Therefore, the surgical operation on the teeth must be exact with a view to helping the establishment of coordinated cusps.

After remedies have been prescribed according to the conditions found and the aims of the dentist, the casts of the prepared teeth are attached to the articulator in place of the diagnostic casts. Then, the restorations are premade in wax.

## CROWN DEVELOPMENT

Certain principles are followed in preforming restorations in wax. The waxed tooth forms are made to grow step by step upon the casts, much as tooth crowns develop embryologically within the undeveloped jaws. In the undeveloped jaw, each multiple-cusp tooth starts to form from a group of isolated cones that grow into lobes which finally coalesce into a single crown. A few years after formation, they erupt into the oral cavity and work their way into occlusion. The cusps may help or hinder proper interlocking of the teeth, depending upon how well the growth of each jaw is paced.

The chief principle in preforming restorations is to place the cusp cones of wax so that, like stalactites, the upper ones hang down at proper intervals among the cones made to rise from the lower tooth preparations. In buccal, lingual, anteroposterior, or any other mandibular border motions, the upper and lower lobes should bypass their opposites without collisions or contacts.

The lobes of each tooth and its opponent are coalesced by waxing on the marginal ridges; this gives the beginning of contour to each crown. The passageways of the conical tips of the lobes are tested again in the various jaw movements to determine if they still provide full freedom for travel during jaw movement.

Finally, the triangular cross-tooth ridges and the oblique ridges are made to connect the lobes. During this procedure, fossae develop naturally in the upper teeth to receive the lower buccal cusps and in the lower teeth to receive the upper lingual cusps in centric position. However, the cusp tips are kept free from closure contacts; each cusp lobe makes point contacts with the perimeter of the fossa. The cusp tip is made not to reach the bottom of the fossa.

## CUSPID DEVELOPMENT

When the cusps of the molars and bicuspids have been fully preformed in wax, careful attention is given to the cuspids. They should be well restored and never neglected. Their closure should harmonize with centric relation. The antagonistic relation of the cuspids should be such that, when the mandible is deflected beyond the chewing cycle, they prevent the meshing of the buccal cusps of the posterior teeth. When the mandible is in the position of protrusive incisive closure, the upper cuspid should strike the buccal surface of the lower bicuspid and the lower cuspid should engage the upper lateral incisor. At the same time, the opposing posterior teeth should be separated.

It is natural to restore the cuspid after the molars and bicuspids have been formed. In the natural development of occlusion, the cuspids of the maxillae descend into occlusion sometime after the bicuspids and the first and second molars are well interlocked.

## PROTECTIVE RELATIONSHIP

There is a mutually protective relationship between the posterior teeth and the anterior teeth. The posterior teeth should interlock, so that they prevent overloading of the anterior teeth. In all lateral overdeflections of the mandible and in all overcyclic incision, the anterior teeth should prevent the posterior cusps from wearing away. In centric relation intercusping, the bodies of the jaws are closest together and any departure from this would entail a separation of the jaws. In other words, the posterior terminal hinge intercusping position is the most closed position of the mandible. This is the cardinal principle for stability of occlusion.

When the mutuality of protection between the posterior and anterior teeth is fully accepted as a principle, we will cease denying the importance of cusps to occlusion. No restraints against wear can be given to the teeth except through cusps. Cusps and cusps alone in their centric-fossa relation can stop and prevent lateral stresses. We cannot restore occlusion well by working only upon the posterior teeth, by just reinstituting good cuspid relations, by leaving the anterior teeth out of centric occlusal contacts, or by grooming the anterior teeth. The restorations must be so integrated that nothing is left undone.

Box 891
VENTURA, CALIF.

# THE CUSPIDS AS SUBSTITUTES FOR THE INCISAL GUIDE PIN

W. G. F. Schmidt, D.D.S.
*Chicago, Ill.*

The production of a satisfactorily functioning occlusion has been the aim of dentists since the inception of dentistry. Despite even a most exacting technique, there has always been something lacking.

Teeth may be arranged on an intricate type of articulator that apparently duplicates the jaw movements, and intercuspation may be developed. The teeth may move without the slightest interference as the articulator is moved in lateral and protrusive movements, and after much tedious effort, we look upon this apparent masterpiece with great satisfaction.

The frustrating result is that when we place the dentures in the patient's mouth he cannot make the free-flowing lateral and protrusive movements that were possible on the articulator.

The fact that the patient cannot make a free lateral movement prevents the restoration from being completely satisfactory. The patient will not be as comfortable as he might be.

## THE CHEWING STROKE

An individual reaches laterally with the mandible and engages the bolus of food; in triturating this bolus, the jaw moves upward and inward until the working-side surfaces of the teeth come together. Then, the mandible glides into centric position, through it, and onto the balancing contacts of what was the working side when the masticating movement began. If this is a true chewing stroke, the patient must be able to move the jaw laterally from centric position.

## POINTS OF GUIDANCE

In an analysis of my efforts, it occurred to me that, on the instrument, I had *three* points of guidance, the two condylar mechanisms and the incisal guide pin. When I put the dentures in the mouth, however, there were only *two* points of guidance, the temporomandibular joints. The incisal guidance was not present in the mouth. Could this be the missing link in our struggle to produce a satisfactorily functioning occlusion?

The only satisfactory substitutes for the incisal guide pin in the patient's mouth are the upper and lower cuspids. The occlusions I have developed had heavy balancing contacts after being placed in the mouth, and the more I attempted to relieve these contacts, the flatter the teeth became. The patient cannot make true

lateral movements when the balancing contacts are too heavy. He will make a protrusive lateral movement instead. If the opposing cuspids on the working side contact in centric occlusion and if the angulation between them is steep enough when the lateral movement is made, the balancing contacts can be prevented from contacting too heavily.

The most satisfactory occlusions I have developed had cuspid contact from centric occlusion to the tip of the upper cuspid. This inclination is developed in harmony with the incisal guidance on the instrument. Then, the working contacts (facets) of the posterior teeth are made to be in harmony with the cuspid contacts, and there are no balancing contacts.

55 East Washington St.
Chicago 2, Ill.

# PRACTICAL APPLICATION OF CURRENT CASTING RESEARCH

WILLIAM J. O'BRIEN, B.S.*
*New York, N. Y.*

ALONG WITH GOOD FIT, a sound, dense casting is a necessity in crown and fixed partial denture work. In the past few years, considerable research has been done on the factors in technique which produce sound, porosity-free castings on a routine basis. It is the purpose of this article to review some of this information in the light of practical applications in the dental laboratory.

In the three most recent studies on this subject, over 1,100 castings were made under different conditions and the results carefully noted. Considering the high costs of scientific research, the readers will certainly benefit by studying the results obtained. The original articles contain detailed classifications of the types of porosity and their causes. Here we are concerned with the practical applications of these findings. Since these studies were made on gold alloys, the results are a function of these materials.

Porosity results from improperly made sprues, back pressure of air in the mold, and too high or too low casting and burnout temperatures.

## SPRUES

It was found that the dimensions of sprues are more critical in preventing porosity than had previously been known.[1] Thin sprues (18 gauge) produced shrinkage porosity with different sprue lengths. The diameter of the sprue had to be larger than the thickest portion of the casting in order to prevent this porosity. For most crowns and inlays, this means that a 12- or 10-gauge sprue is needed to prevent localized shrinkage porosity. The reason for this is that the sprue channel, as the supplier of molten metal to the solidifying casting, must be the last to solidify. As molten metals pass from the liquid to the solid state, a contraction in volume takes place. If this decrease is not followed by a flow of molten metal from the sprue, pores will be left in the casting.

It is well known that coffee will cool more quickly in a saucer than in a cup because the surface area is greater in the saucer. The same holds true for metal

*Associate Director of Research, J. F. Jelenko & Company, Inc.

castings, and the relationship of surface area to bulk of the sprue has to be adjusted so that the sprue is last to freeze.

In addition to the thickness of the sprue, the sprue length was closely linked to porosity.[1] The optimum sprue length was found to be 9 mm. Shorter sprues, even with the correct diameter, gave more porosity than the 9-mm. sprue. The sprue should be placed at the bulkiest portion of the casting, and if thin sections separate bulky ones, sprues should be made in both heavy portions.

### CASTING TEMPERATURE

The casting temperature was also found to have an ideal range.[1] This was found by experiment to be approximately 100° to 150° F. above the melting range of the gold. Lower casting temperatures produced microporosity and gas inclusions. Subsurface porosity was found with higher casting temperatures. In order to regulate the temperature factor, a pyrometer is necessary.

### BURNOUT TEMPERATURE AND BACK-PRESSURE POROSITY

*Effect of Burnout Temperature on Soundness of Castings.*—The temperature of the investment mold was found to influence "back-pressure porosity."[2] Back-pressure porosity is usually found as pits on the inner surface of crowns. This

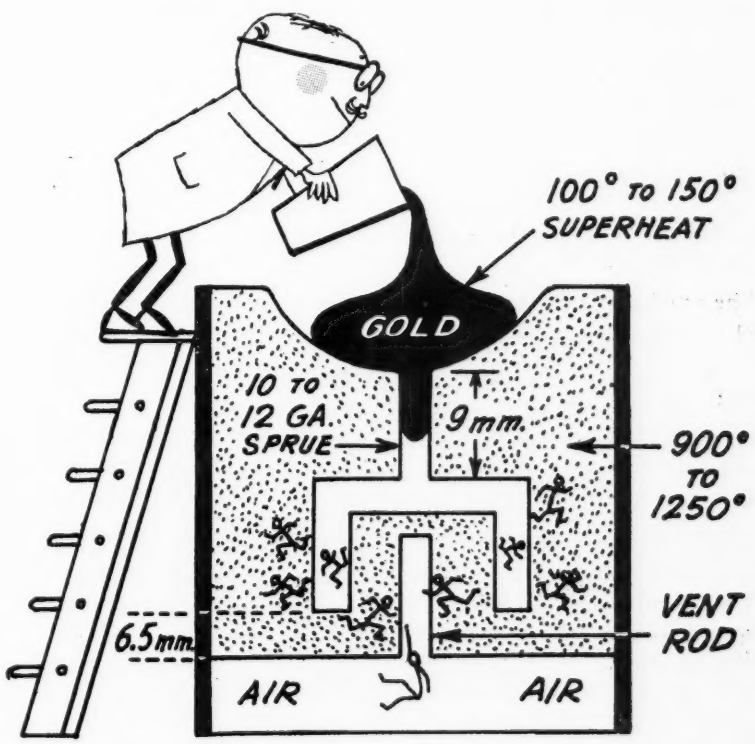



Fig. 1.—As gold enters the mold, trapped air escapes through the investment and the air vent rod. This is symbolized by the little stick men.

results when mold gases do not escape quickly enough as the molten alloy shoots down the sprue channel.[4] In other words, the air in the mold pushes back on molten gold during the casting operation. Hygroscopic low burnout techniques produce more of this porosity.[2,3] This has been attributed to a low water-powder ratio and incomplete elimination of the wax.[2]

Several techniques may be used to eliminate this porosity when a low burnout temperature is desired.[2-4] All of these methods aim at increasing the pressure of the molten alloy over that of the gases in the mold. This can be done by increasing the number of turns on a centrifugal machine,[2] increasing the casting pressure on a pressure casting machine,[4] performing the casting operation in a vacuum,[2] flaring the sprue and its attachment to the casting,[3] keeping the distance from the top of the pattern to the outside of the investment to ¼ inch, providing vents through which the mold gases can escape (Fig. 1), and using more metal.[2]

*Factors in Eliminating Back-Pressure Porosity.*—The following factors provide the best conditions to eliminate this type of porosity with a low burnout temperature. It is important to note that each one of these factors works separately, so that all of them may not be necessary.

1. Three to four turns on a centrifugal casting machine increase the casting pressure.[2]

2. When using a pressure casting machine, 20 pounds per square inch is recommended.[2]

3. The distance of the wax pattern from the end of the investment should be ¼ inch.[2]

4. In order to provide a path for the mold gases to escape, a vent rod suspended in the center of the crown, but not touching the actual casting, has been found to be helpful.[2]

5. Slight flaring of the sprue at its attachment to the pattern[3] has been found to reduce this type of porosity.

6. Enough gold should be used so that the button obtained weighs the same as the casting proper.[2]

7. The mold temperature should be between 900° and 1,250° F.[1] Time should be allowed in order for the mold to reach the temperature of the furnace.

REFERENCES

1. Ryge, G., Kozak, S. F., and Fairhurst, C. W.: Porosities in Dental Gold Castings, J.A.D.A. **54**:746, 1957.
2. Strickland, W. D., and Sturdevant, C. M.: Porosity in the Full Cast Crown, J.A.D.A. **58**:69, 1959.
3. Asgar, K., and Peyton, F. A.: Pits on Inner Surfaces of Cast Crowns, J. Pros. Den. **9**:448, 1959.
4. Phillips, R. W.: Studies on the Density of Castings as Related to Their Position in the Ring, J.A.D.A. **35**:329, 1947.

136 West 52nd. St.
New York 19, N. Y.

# CLASS V RESTORATIONS

JOHN H. MOSTELLER, D.D.S.
*Mobile, Ala.*

ALTHOUGH CLASS V RESTORATIONS are considered to be rather simple operations by most dentists, clinical observation will reveal a large number of failures of these fillings. Failures are usually due to (1) poor cavity preparation, (2) selection of the wrong restorative material, or (3) faulty manipulation of the selected material. I shall evaluate the available materials for placement in Class V cavities and then present my technique for the material of choice.

## SILICATE CEMENT

The toxic effect of silicate on the pulp is well established.[1,2] At one time pulpal death was very common due to the irritation of orthophosphoric acid. In 1949 Glass and Zander[3] reported true healing of exposed pulps when treated with calcium hydroxide, and a year later Zander and Nelson[4] demonstrated the ability of this chemical, when used as a cavity liner, to eliminate the pulpal damage caused by silicate. While it is now possible to eliminate the irritating quality of this filling material, its physical properties still must catalogue it as a temporary filling only.

Work with radioactive isotopes[5] has indicated that all fillings leak microscopically, but since restorations are observed daily that have served patients for decades, we are not too disturbed about the clinical significance of this microscopic leakage. Comparative autographs demonstrate that the isotope not only leaks around the margins of silicate but also penetrates directly through the filling material itself. This is due, of course, to the great porosity of the material, which results in very unsightly staining of silicate fillings in most patients' mouths in a matter of months. Although silicate is used in a very large percentage of the Class V cavities found in the anterior part of the mouth because of its supposed esthetic superiority to other more permanent materials, a badly stained silicate filling is certainly more objectionable from a cosmetic standpoint than is a small piece of well-polished silver or gold. Stained silicate certainly gives the appearance of a neglected mouth, for it looks similar to caries.

Silicate is also soluble in the saliva and thus continuously washes out of the cavity. Recent work published by Phillips[6] showed this solubility to be greater in an acid media, and thus it would appear that silicate will dissolve faster in the

Presented before the 89th Annual Meeting of the Alabama Dental Association, Montgomery, Ala.

Revised from Journal of the Alabama Dental Association 42:8-17, 1958, by permission of the editor.

mouths of patients with rampant caries. Although silicate does wash out and soon develops very poor margins, we seldom see recurring caries around silicate fillings. This has been attributed to a reduction in the solubility of enamel contiguous to silicate.[7] The reduction in solubility is believed to be due to the fluoride content of the filling material. The continuous washing away of the silicate, coupled with its inherent lack of resistance to wear, results in a very short clinical life for Class V silicate fillings, which are constantly bathed in the gingival secretions and subjected to the abrasion of the toothbrush.

### SELF-POLYMERIZING ACRYLIC RESIN

Several years ago autocuring acrylic resin was enthusiastically accepted by many dentists, much to their later regret. If the physical properties of this material had been studied, the failures could have been predicted. The linear coefficient of thermal expansion of acrylic resin is over seven times that of the tooth, and thus acrylic resin expands or contracts more than seven times as much as the tooth when the patient consumes hot or cold foods and beverages. Nelson and his co-workers[8] at the National Bureau of Standards demonstrated the marginal percolation that occurs around all acrylic resin fillings. In contrast to the microscopic leakage that occurs around all filling materials, this gross fluid exchange does have very definite clinical significance.

A recent study in Sweden by Hedegard[9] disclosed carious dentine under approximately 60 per cent of a rather large number of acrylic resin fillings which were removed. Acrylic resin, unlike silicate, does not possess any anticariogenic property. While Phillips and Swartz[10] have suggested the possible addition of fluoride to acrylic resin filling material in an effort to reduce the solubility of the adjacent enamel margins, much clinical investigation will have to be completed before the use of such a restorative material can be recommended to the dental profession.

The earliest historical work with acrylic resin reported that it was noninjurious to the pulp,[11] but later work by Nygard-Ostby[12] demonstrated frequent pulpal necrosis and abscess formation. Lefkowitz[13] has explained this discrepancy in the work of equally reputable histopathologists on the basis of the difference in length of time the fillings were allowed to remain in the tooth before sectioning. The earlier work was done after the fillings had been in the mouth only a very short period of time. It appears that while acrylic resin is not an irritant to the pulp per se, the percolation that constantly occurs around these fillings results in pulpal inflammation and even necrosis after a longer period of time.

Stebner[14] conducted a survey among five outstanding restorative dentists and five nationally known research men who evaluated gold foil, silicate cement, and acrylic resin as restorative materials for Class III, IV, and V cavities. This group graded gold foil 83, silicate 59, and acrylic resin 50 out of a possible 100 for the at present unavailable perfect or ideal restorative material. While I agree with the marked superiority of gold foil over the other two materials, we cannot judge acrylic resin as a close third to silicate. As poor a material as silicate is, it has saved teeth for many years, while the status of teeth filled with acrylic resin is doubtful, to say the least.

### SILVER AMALGAM

Silver amalgam can serve well in Class V cavities if the cavity is prepared properly and the material is manipulated correctly. Unfortunately, many dentists consider a Class V cavity such a simple procedure that seldom is the proper time and detail given to the design and execution of the cavity preparation; and the failure of most dentists to routinely use the rubber dam and thus exclude moisture from the amalgam results in the old "amalgam line" which is so frequently observed around Class V amalgam restorations. Even the well-fabricated amalgam will corrode under the free margin of the gingiva, which is the correct location of the gingival margins of all Class V restorations. This feature alone makes amalgam inferior to gold foil and practically precludes its use in the anterior portion of the mouth.

### GOLD INLAY

Although casting procedures have been perfected during the last 20 years and the accuracy of the elastic impression materials has been attested, we see little place for the gold inlay in Class V cavities. We have observed few excellent Class V inlays, and even these teeth could have been restored in less time and at less expense with gold foil. Irregularities in cavity design so often necessary in Class V areas frequently preclude the use of an inlay even by the most proficient dentist. The gold foil is definitely superior in its adaption to the cavity walls and can be used by any dentist willing to utilize the technique presented in this article.

### GOLD FOIL

Gold foil is certainly the material of choice. It comes closest to hermetically sealing the cavity, it can be well contoured to protect the integrity of the contiguous soft tissue, it does not corrode even though placed below the free gingival margin, and it will not deteriorate with age. One of the best features of the material is that it demands an exacting technique which assures good results. One sees few poor gold-foil restorations. The dentist either builds a good gold-foil restoration or no filling at all. The more gifted and the more experienced will produce more nearly perfect foil fillings, but even the less classic gold-foil filling is far superior to one built of any other material in the Class V area. Any dentist who regularly builds gold-foil fillings in his practice can not help but become more critical of his other efforts and develop into a better dentist.

With a little experience, the following technique will allow the average dentist to build an excellent Class V gold-foil filling in approximately 1 hour and 15 minutes. Many patients desire the best service available, and any dentist who does not offer gold-foil restorations to his patients is neglecting these individuals. When the difference in service is explained to the patients, a commensurate fee can be obtained, and the building of gold-foil fillings becomes very rewarding both economically and professionally.

### RUBBER DAM

One of the prime requisites in the successful placement of any type of Class V restoration is to expose the gingival margin of the cavity. If the gingival crevice is

exceptionally deep, I do not hesitate to excise it as is done in performing a partial gingivectomy. Soon after healing, it will regenerate to a normal depth and cover the gingival margin of the filling, as is desired. If the gingival crevice is of normal depth, I retract it with an epinephrine-impregnated string, such as Gingi-Pak,* which most dentists use to expose the margins of cavities when employing any elastic impression material. I pack the gum tissue back at least a full millimeter below the planned gingival margin of the cavity. The rubber dam is then applied.

I use a dark, heavy dam which offers contrast for facilitated vision and body for facilitated passage through the interproximal contacts of the teeth. The template designed by Stebner† serves as a guide for marking the indicated holes in the dam and the largest punch is routinely used. This is still smaller than the circumference of the smallest tooth and this again facilitates the placement of the dam. The tissue side of the dam is lubricated with shaving cream to further facilitate its passage through the contact areas. Where possible, one or two teeth on each side of the

Fig. 1.—A secured cervical clamp.

tooth to be prepared are isolated with the dam. The dentist stretches the lubricated dam over the predetermined teeth and the assistant stands at the left of the chair ready to pass a piece of dental floss through any interproximal contact which offers the least bit of resistance to the passage of the dam. The terminal teeth may be used to secure the dam with ligatures of dental floss, but usually it is simpler to pass a small piece of rubber cut from the corner of the dam through the contact between the terminal tooth and its adjacent member of the arch.

Next the cervical clamp, either an Ivory No. 9 or an S.S. White Ferrier No. 212, is placed on the tooth to be prepared. A rubber dam clamp forcep is employed to open the bows of this clamp, and the dam and the gingival tissue are retracted at least a full millimeter below the level of the planned gingival margin of the cavity. The clamp is secured by placing flame-softened, black-stick, low-fusing compound beneath and over both of the bows. The compound is molded into proper place with moistened fingers and hardened by a generous blast of compressed air. A saliva ejector may now be placed under one corner of the dam. A dry clean field is now assured for the operation (Fig. 1).

*Surgident, Ltd., West Los Angeles 25, Calif.
†Hygienic Dental Mfg. Co., Akron 8, Ohio.

CAVITY PREPARATION

The outline form we use is the Ferrier type preparation. The occlusal and gingival margins are made parallel with the occlusal surface of the tooth and are connected by slightly oblique proximal cavity walls. These proximal walls diverge buccally toward the proximal embrasures in order to respect the direction of the enamel rods in these areas. The most common error in Class V preparations is to undermine the enamel on the proximal walls of the cavity. No retention is obtained at the proximoaxial line angles. Fig. 2, *A,* shows the correct and incorrect cross section of a Class V cavity, as suggested by Ingraham.[15] Fig. 2, *B,* presents the correct and incorrect outline form of this same cavity. The straight occlusal margin is more harmonious from a geometric standpoint and is also easier to establish than is the frequently seen curved one. Chisels and other hand cutting instruments can be more easily applied to straight margins and the less acute occlusoproximal angles reduce the opportunity for leaving weak enamel rods. Both the occlusal and the

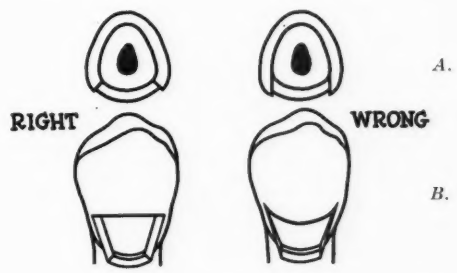


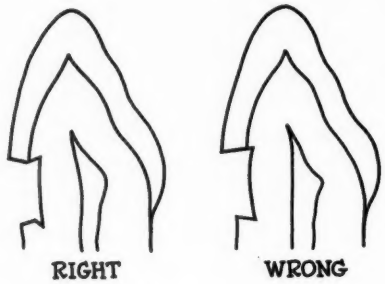

Fig. 2, *A* and *B*—The occlusal and gingival margins are parallel with the occlusal line of of the tooth, and both are generously beveled. The proximal cavity walls diverge toward the proximal embrasures. There is no undercut at the proximoaxial line angles.

gingival margins are beveled generously, while the buccal divergence of the proximal walls requires only a very slight bevel of these margins. It will be noted that the pulpal or axial wall follows the convexity of the buccal surface of the tooth to give sufficient depth to the proximoaxial line angles. These line angles are sharp but no undercut is established.

Fig. 3, *A,* is a longitudinal section of the preparation, and it should be noted that both the occlusal and the gingival walls of the cavity diverge toward the buccal surface of the tooth. This is to respect the direction of the enamel rods in these areas, thus preventing failure of weak unsupported rods and the reflection of the gold beneath these margins. The retention is obtained along the occlusoaxial and gingivoaxial line angles. There are no convenience or retention points, but the retention is along the full length of these two line angles. Fig. 3, *B,* pictures the frequent error of converging the occlusal and gingival walls toward the buccal surface of the tooth.

INSTRUMENTATION

The cavity is opened with a small inverted-cone bur, usually size 33½. The occlusal wall is roughly established by running the bur mesiodistally on a straight




*A.* *B.*

Fig. 3, *A* and *B*—The occlusal and gingival walls of the cavity diverge toward the buccal surface of the tooth along the direction of the enamel rods. The retentions are placed the full length of the occlusoaxial and gingivoaxial line angles.*

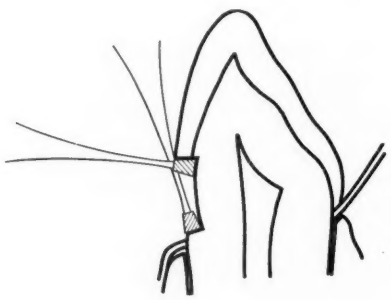


Fig. 4.—The occlusal and gingival walls are roughly established with a small inverted-cone bur.

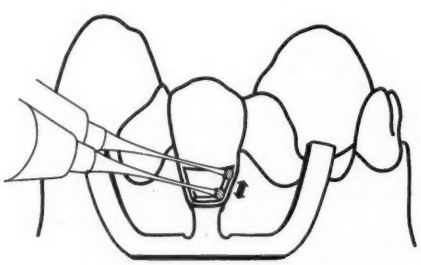


Fig. 5.—The proximal walls of the cavity are roughly established with the same bur.

line at a height placing this margin above the area of caries or erosion. The gingival wall is next established with the same bur, holding the end of the cutting instrument so that it cuts the desired divergence of this wall toward the buccal surface of the tooth (Fig. 4).

Without changing cutting tools, the proximal walls are flared toward the proximal embrasures, running the bur occlusogingivally as shown in Fig. 5. The desired

*Figs. 3 through 6 are from Koser, J. R., and Ingraham, R.: Mat Gold Foil With a Veneer Cohesive Gold Foil Surface for Class V Restorations, J.A.D.A. 52:714-727, 1956; Figs. 2 and 7 through 16 are redrawn using the basic Class V cavity illustration of that article.

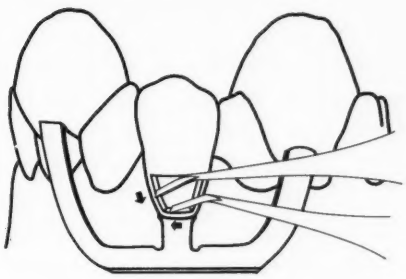


Fig. 6.—All four cavity walls are finished with hand instruments and the occlusal and gingival margins are beveled.

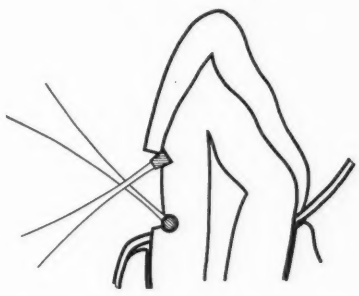


Fig. 7.—Retentions are placed along the full length of the occlusoaxial and gingivoaxial line angles with a small bur.

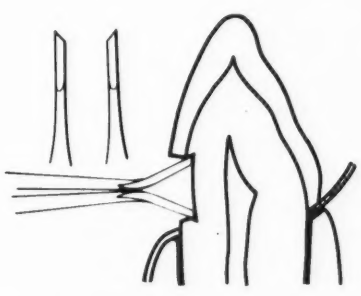


Fig. 8.—Angle formers are used to sharpen the retentions. This same pair of instruments is also used to define the proximoaxial line angles, but no undercut is established at the latter.

buccal divergence of the occlusal, gingival, and both proximal walls is more definitely established by the use of hand instruments. In the case of the occlusal and gingival walls, the cutting instrument is used mesiodistally, while the proximal walls are established in an occlusogingival direction. The proximoaxial line angles are well defined at this same time (Fig. 6).

The retentions are now placed the full length of the occlusoaxial and gingivoaxial line angles with either a ½ round or 33½ inverted-cone bur, running the bur mesiodistally (Fig. 7). Angle formers are next employed to sharpen and define these long retentions, pulling the sharp instruments back and forth mesiodistally a number of times (Fig. 8).

BUILDING THE FILLING

We use the combination mat and cohesive gold-fold technique first suggested to us by Ingraham,[15] described by Myers,[16] and taught to us by Stebner[17] and Vernetti.[18] Mat gold is a crystaline form of pure gold formed by electrolysis. It is supplied in ribbons which have not been treated with ammonia gas as are cohesive pellets. Nevertheless, we like to anneal our pieces of mat gold to assure complete purity. A piece of mat gold which approximates the size of the outline form of the cavity is cut from the ribbon and annealed by the dental assistant over an open alcohol flame. More elaborate annealers are commercially available, but we still

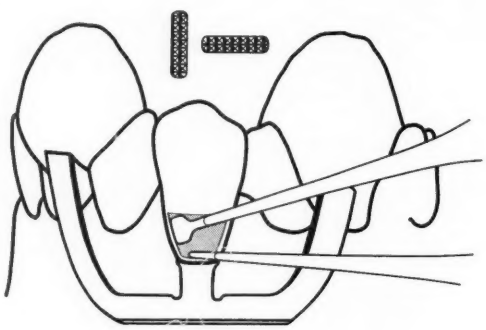


Fig. 9.—The first cantle of mat gold is condensed into the retentions and proximoaxial line angles by parallelogram-shaped hand condensers.

prefer the open flame as do many fine gold-foil operators. The annealed piece of mat gold is carried by the dental assistant to the cavity where the dentist condenses it into the occlusoaxial and gingivoaxial retentions with parallelogram hand condensers designed for amalgam. The mat is also condensed along the proximoaxial line angles with the same set of two instruments (Fig. 9). During this condensation, the mat gold is held in place by a gold-foil holder in the left hand of the dentist.

Mat gold is very brittle and does not pack well under mechanical condensation; for that reason this first large cantle of mat gold is now covered with an exceptionally large pellet of cohesive foil which serves as a matrix. Cohesive foil is supplied

Fig. 10.—A pellet of cohesive foil is used as a matrix over the hand-condensed mat and then condensation is carried out mechanically. The retentions and the proximoaxial line angles are filled first.

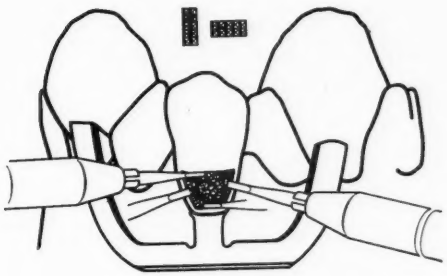


Fig. 11.—Margins are completed with cohesive gold foil condensed by parallelogram-shaped condenser points in either a pneumatic or electronic instrument.

either in sheets, from which the dentist may roll his own pellets of desired size, or in prerolled pellets of different sizes. We utilize the pellets in our practice. In either physical form, the gold is treated by the manufacturer with ammonia gas to make it noncohesive and this gas must be removed by annealing. Again we use the open alcohol flame. We do not wish to burn the gold, but the dental assistant holds the pellet in the flame until it reaches a bright red and then immediately removes it, allowing a slight interval for cooling before placing the pellet in the cavity of the tooth.

The pellet is placed by the dental assistant so as to cover one of the retentions and is then condensed with a small round plugger point in either the Hollenback* pneumatic or McShirley† electronic condenser. At the present time we are using the

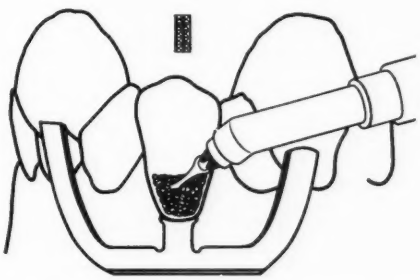


Fig. 12.—The center portion of the filling is built with cohesive pellets using a foot plugger in an automatic instrument.

McShirley instrument. This pellet is held in proper place with a gold-foil holder or "assistant" in the left hand of the dentist (Fig. 10). Other pellets are used to condense the mat gold into both retentions and the proximoaxial line angles. This procedure is repeated, that is, we place another piece of mat gold, which is covered and condensed with cohesive pellets, so that approximately two-thirds of the cavity is filled. After the first pellets are condensed over the mat, the gold-foil holder may be placed aside, for each succeeding piece of mat gold or pellet of cohesive foil will adhere to the previously condensed mass without the aid of the holder. The filling

*Cleveland Dental Mfg. Co., Cleveland, Ohio.
†McShirley Products, Glendale, Calif.

can be built very rapidly in that the dental assistant can anneal and carry the gold to the cavity and the dentist does not need to look up from the field of operation. The joy of building a gold-foil filling with such ease is beyond description.

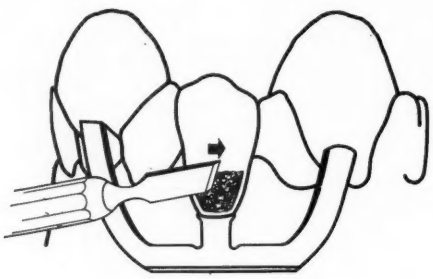


Fig. 13.—Heavy Marquis gold-foil knives Nos. 1 and 2 are used to trim the occlusal margin of the filling.

After the major portion of the filling has been built with the combination mat gold and cohesive foil technique, the external surface of the restoration is fabricated with cohesive pellets, condensing the four marginal areas first with parallelogram-shaped condenser points in an automatic instrument (Fig. 11). The center portion of the filling is the last part that is built, and this is done only after all four margins have been completed. Care must be taken to condense on the gold filling in the cavity and not against the enamel margins of the cavity. The filling should be fully built and then carried over the beveled margins. Working in this manner, the margins will be cushioned and protected by the gold. The condenser point must never be placed against the margin of the cavity until it has been built flush with the gold filling.

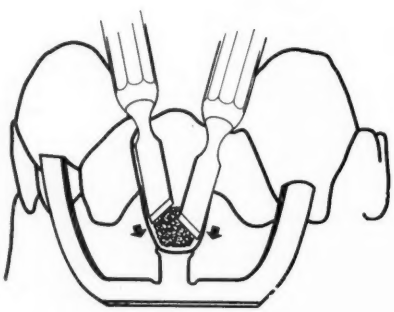


Fig. 14.—These same knives are used on the proximal margins. The point of the blade of the knife is always away from the filling in order to allow it to rest on sound tooth structure which served as a guide in trimming.

The center portion of the restoration is then built with cohesive pellets using a foot plugger of appropriate size (Fig. 12). Unlike amalgam, excess is not indicated at the marginal areas but it is only necessary to build the filling flush with well-

condensed gold. This thorough condensation is achieved by stepping the condenser over each pellet of foil several times, allowing the condenser point to overlap the previously condensed portion. A slight excess should be built in the center of the

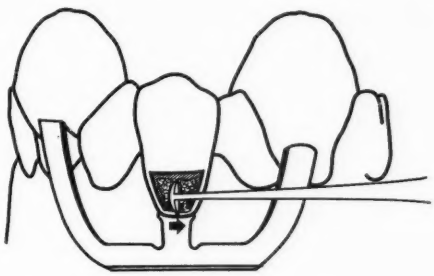


Fig. 15.—A Jones gold-foil knife is used to trim the gingival margin of the filling. This is a pull knife, as the arrow indicates.

restoration to allow for the removal of gold during the contouring and finishing of the filling. Two normal convexities must be restored—one running mesiodistally and one running gingivo-occlusally to protect the contiguous gingival tissue.

### FINISHING THE FILLING

There is no substitute for sharp knives for establishing definite margins on gold-foil fillings. The occlusal margin is carved with a very heavy Marquis gold knife (Fig. 13). This knife is beveled on an angle and is a push knife, as the arrow in the illustration indicates. The point of the knife is always held away from the filling to serve as a guide against the intact buccal surface of the tooth. The proximal margins of the filling are likewise carved with this set of Marquis knives Nos. 1 and 2 (Fig. 14). The only difference between these knives is the direction of the blade points. This is achieved by beveling the blades on opposite sides. Again the point of the knife is held away from the filling to allow it to rest on the intact proximal surface of the tooth. The placement of the blade point away from the filling will automatically indicate which knife should be used for each margin of the filling, whether it be the occlusal or the proximal. Gold should be carved in small shavings and at no time should the dentist attempt to take big "bites" of the filling material.

The gingival margin is carved with a special Jones gold-foil knife, which is a pull knife as Fig. 15 indicates. This is a very delicate knife that will cut only small shavings, which is the correct manner in which to trim this margin. Care must be taken not to cut into the relatively soft cementum adjacent to the gingival margin of the filling. Again we emphasize the importance of leaving all four margins exposed during the condensation of the filling. The beveled margin is slightly covered only after the filling has been built flush. The tendency of the uninitiated dentist is to build marked excess at the margins; this will only make the carving of these margins more tedious and difficult.

The contour of the central portion of the filling is established with medium-grit sandpaper disks as shown in Fig. 16. The two convexities—one running mesio-distally and the other running gingivo-occlusally—replace the natural anatomy of the tooth. At all times when sandpaper disks are employed, the filling should be well coated with petroleum jelly, not only to reduce the chance of overheating the tooth

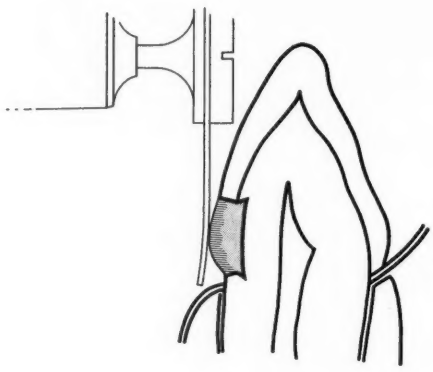


Fig. 16.—Medium-grit sandpaper disks followed by cuttle disks are used to finish down the filling and establish the desired contour. There are two convexities to restore—one running mesiodistally and the other running occlusogingivally. The filling should be well coated with petroleum jelly while being contoured.

Fig. 17.—A completed Class V gold-foil restoration in the mouth.

but to reduce the formation of scratches on the buccal surface. This point cannot be overemphasized. The sandpaper disks are followed by cuttle disks and the final polish can be created by the use of fine pumice and chalk applied with a rubber cup. For esthetic reasons, we prefer a velvet-smooth surface rather than a sparkling appearance. A completed Class V gold-foil filling is illustrated in Fig. 17.

## SUMMARY

The available restorative materials have been evaluated as to their applicability in Class V cavities, and it has been concluded that gold foil is still the material of

choice. While the dental caries problem can never be solved with the exclusive use of gold foil, there are many patients who desire the best service available and it is the obligation of all dentists to provide this service to their patients. The reason more gold-foil fillings are not made in the United States is that too few dentists offer this service to their patients. With a little experience and a little patient education, the financial reward from building gold-foil fillings will more than compensate for the time and effort necessary to learn the technique.

REFERENCES

1. Manley, E. B.: Preliminary Investigation Into Reaction of the Pulp to Various Filling Materials, Brit. D. J. **60**:321, 1936.
2. Zander, H. A.: Reaction of Dental Pulps to Silicate Cement, J.A.D.A. **33**:1233, 1946.
3. Glass, R. L., and Zander, H. A.: Pulp Healing, J. D. Res. **28**:97, 1949.
4. Zander, H. A., Glenn, J. F., and Nelson, C. A.: Pulp Protection in Restorative Dentistry, J.A.D.A. **41**:563, 1950.
5. Armstrong, W. D., and Simon, W. J.: Penetration of Radiocalcium at the Margins of Filling Materials: Preliminary Report, J.A.D.A. **43**:684 1951.
6. Norman, R. D., Swartz, M. L., and Phillips, R. W.: Studies on the Solubility of Certain Dental Materials, J. D. Res. **36**:977, 1957.
7. Phillips, R. W., and Swartz, M. L.: Effect of Fluoride on Hardness of Tooth Enamel, J.A.D.A. **37**:1, 1948.
8. Nelson, R. J., Wolcott, R. B., and Paffenbarger, G. C.: Fluid Exchange at Margins of Dental Restorations, J.A.D.A. **44**:288, 1952.
9. Hedegard, Bjorn: Cold-Polymerizing Resins as Restorative Materials: A Clinical Evaluation, Odont. tskr. **65**:169, 1957.
10. Phillips, R. W., and Swartz, M. L.: Effect of Certain Restorative Materials on Solubility of Enamel, J.A.D.A. **54**:623, 1957.
11. Seelig, A.: Effect of Direct Filling Resins on the Tooth Pulp. J.A.D.A. **44**:261, 1952.
12. Nygaard-Ostby, B.: Pulp Reactions to Direct Filling Resins, J.A.D.A. **50**:7, 1955.
13. Lefkowitz, W.: Personal Communication.
14. Stebner, C. M.: Role and Evaluation of Gold Foil, Silicate Cement, and Acrylic Resins in Operative Dentistry, J.A.D.A. **53**:661, 1956.
15. Koser, J. R., and Ingraham, R.: Mat Gold Foil With a Veneer Cohesive Gold Foil Surface for Class V Restorations, J.A.D.A. **52**:714, 1956.
16. Myers, L. E.: Filling a Class V Cavity With a Combination Mat and Cohesive Gold Foil, J. Pros. Den. **7**:254, 1957.
17. Stebner, C. M.: Personal Demonstration.
18. Vernetti, J. P.: Personal Demonstration.

1729 Springhill Ave.
Mobile, Ala.

# ULTRA-SPEED AND AUXILIARY EQUIPMENT IN FIXED PARTIAL DENTURE CONSTRUCTION

H. C. KILPATRICK, D.D.S.
*New Canaan, Conn.*

ULTRA-SPEED CUTTING PROCEDURES have made reduction of tooth structure less time consuming and arduous for both patient and dentist. The purposes of this article are (1) to show how several types of ultra-speed handpieces can be used in succession to prepare teeth, (2) to suggest a simplification of cutting tools, (3) to show by an electronic measuring device the actual cutting speed used for each cut, (4) to show a method of making an impression by using the check-bite tray, hydrocolloid impression material, and Die-Lok procedures so that a fixed partial denture can be completed in two appointments, (5) to show how high and ultra speed can be used by the dentist in the laboratory and try-in phase, and (6) to show auxiliary equipment that has a place in the above procedures.

## ULTRA-SPEED CUTTING EQUIPMENT

Ultra-speed cutting equipment is of three types: gear-, belt-, and turbine-propelled. Examples are the Midwest Gear Drive (up to 125,000 r.p.m.), the Page-Chayes (up to 200,000 r.p.m.), the Kerr Super-Speed (up to 150,000 r.p.m.), and the air turbines (up to 400,000 r.p.m.) (Fig. 1). The air turbines are the Borden, Densco, Star, Midwest, and Weber. Many other ultra-speed devices are being tested and will be available. Better units designed for easier and more efficient ultra-speed operation are available and are being constantly improved.

McKay[1] observed that, "Each dentist must decide for himself, through investigation and use, the type of equipment best suited to the requirements of his practice. None of us can be expected to clutter up our offices in an attempt to use all of the various instruments and techniques that are available today."

All of the instruments I investigated were adequate, but for simplification in this technique, one belt-driven and two air-turbine contra-angle instruments were used for the cutting in the mouth. Air turbines are made much more versatile by the addition of a variable foot control.

At ultra speed, diamond stones seemed to cut best in enamel. However, cutting tools of the same make and shape varied greatly in their ability to cut.[2] Preliminary

Presented as a projection clinic before the Greater New York Academy of Prosthodontics, New York, N. Y.

tests of the instruments used in cutting should be made and these instruments set aside for work in the mouth.

The cutting instruments were from several different manufacturers (Fig. 2). There were (1) a No. 558 carbide bur by S. S. White, (2) a chamfering stone, Star P21L, and (3) a finishing stone, Densco F1A. These three instruments were the

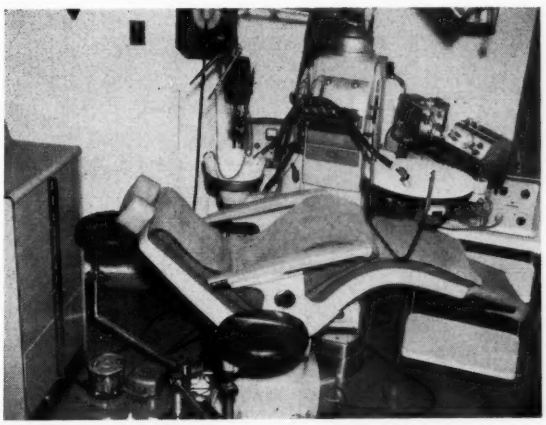


Fig. 1.—A group of high- and ultra-speed handpieces and auxiliary equipment. At the upper left, the Page-Chayes contra-angle and Chayes ball-bearing straight handpieces, with the S. S. White ball-bearing contra-angle instrument, are mounted on a dual-arm transmission. Hydroceptor tubing powered by Vacudent is on the bracket table. Densco and Midwest air turbines are mounted on bracket table arm. The McShirley electronic mallet and Cavitron prophylaxis unit are at the rear of the unit. The removable Junior insert is on the Euphorian chair. Twin Castle T & M operating stools are on either side of the chair. The auxiliary cabinet is at the rear of the chair.

Fig. 2.—Cutting instruments and ultra-speed contra-angle instruments. At the far left, a No. 1½ Rode diamond for trimming gingival margins. In the center, from top to bottom, a No. 558 carbide bur, a Star P21L chamfering stone, and a Densco F1A finishing diamond (note the small magnet soldered to the shank of this diamond for electronic pick-up). At the right, from top to bottom, the Page-Chayes handpiece, the Densco Aero Turbex handpiece, and the Midwest Air Drive.

TABLE I. SHAFT SPEEDS DURING TOOTH PREPARATIONS, MEASURED WITH AN ELECTRONIC PICK-UP*

| INSTRUMENT | METHOD | IDLE SPEED (R.P.M.) | SPEED DROPPED TO WHEN CUTTING ENAMEL (R.P.M.) | SPEED DROPPED TO WHEN CUTTING DENTINE (R.P.M.) |
|---|---|---|---|---|
| Page-Chayes belt-driven handpiece | No. 558 carbide bur, 2- to 4-ounce touch | 156,000<br>204,000 | 138,000<br>192,000 | 144,000<br>196,000 |
| | Brush technique, chamfer stone | 156,000 | 150,000 | 152,000 |
| Midwest air-turbine instrument | Instrument at 30 p.s.i., with a No. 558 carbide bur, 2- to 4-ounce touch | 252,000 | 220,000 | 240,000 |
| | Instrument at 20 p.s.i., with a No. 558 carbide bur, 2- to 4-ounce touch | 196,000 | 168,000 | 180,000 |
| | Brush technique, chamfer stone | 252,000 | 240,000 | 236,000 |
| Densco air-turbine instrument | Instrument at 32 p.s.i., with a No. 558 carbide bur, 2- to 4-ounce touch | 372,000 | 240,000 | 312,000 |
| | Brush technique, chamfer stone | 324,000 | 312,000 | 312,000 |

*All measurements are approximate and varied with different turbines of the same make.

only ones used for the entire tooth preparation and they can be left in the handpieces for the duration of the cutting. However, any cutting instrument may be substituted for those suggested. Adequate cooling with water is essential with all high- and ultra-speed cutting.

## MEASURING CUTTING SPEEDS

The actual shaft cutting speeds were measured by an electronic device (Fig. 3). A small magnetic bar is soldered to the shank of the cutting tool near the part which emerges from the bur tube.[3] Around this magnet is arranged a circle of metal which intensifies the magnetic field. A coil of fine wire in one side of the metal ring cuts the magnetic field each time the magnetized bar revolves and an electric current is generated. This current is carried to an amplifier, which strengthens the current so that it can be measured by a frequency meter calibrated to indicate the current in revolutions per minute. The faster the cutting tool moves, the greater is the frequency of current generated (and vice versa). In this manner, the exact rotational shaft speed can be measured while the cutting tool is under load.

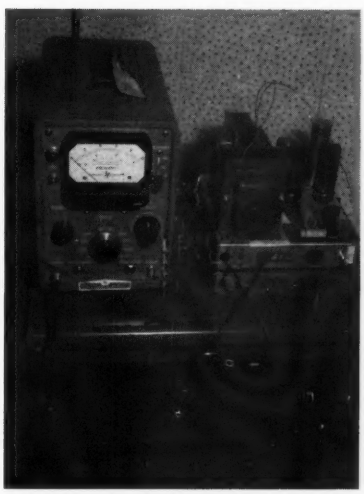


Fig. 3.—Electronic equipment was used to measure cutting speeds of equipment. At the right, an amplifier; at the left, a frequency meter.

## PREOPERATIVE PROCEDURES

Study casts and roentgenograms were analyzed to determine the type of fixed partial denture to be used. The construction of a full-coverage, broken stress, sanitary pontic, three-unit fixed partial denture with an acrylic resin veneer crown on the second bicuspid and a full-cast crown on the second molar will be described.

The cuts for a chamfer-type preparation are outlined on the study cast and the roentgenograms checked for pulpal clearance. Reduction of opposing cusps is indicated where necessary.

OPERATIVE PROCEDURE

A Justi silicone impression is made of the quadrant of teeth to be prepared and is used in the fabrication of temporary acrylic resin crowns. This impression is set aside.

A No. 558 carbide bur mounted in the Page-Chayes contra-angle handpiece is used to make the initial interproximal cuts with a pressure of 2 to 4 ounces. The revolutions per minute of these cuts are shown in Table I. The same bur is used with the same pressure to reduce the occlusal, lingual, and buccal surfaces to the desired outline, leaving a complete shoulder just below the free margin of the gingivae. The change in revolutions per minute when cutting dentine, as indicated by the frequency meter, is seen also in Table I. For purpose of comparison, the No. 558 bur and chamfer diamond stone were interchanged with the air turbines for the same cutting procedure (Tables I and II).

The chamfer-type stone mounted in a Densco contra-angle instrument is used to prepare the desired chamfer form and definite finishing line below the free margin of the gingival tissue. The chamfer is cut below the shoulder left by the No. 558 bur. This same cutting instrument is used to establish the occlusal contour and reduce the opposing cusps. The revolutions per minute of this cutting instrument are seen in Table I.

A finishing diamond stone is used in the Midwest turbine at 20 p.s.i. to finish and smooth the rough cuts left by the bur and coarse stone. The difference in revolutions per minute for this procedure is seen in Table II.

Remaining gingival tissue is removed with a No. 1½ coarse Rode diamond stone in a Page-Chayes contra-angle handpiece. The revolutions per minute for this procedure are seen in Table II.

Any handpiece used in this technique may have the cutting instruments interchanged and can be used to perform any of the tooth preparation procedures.

IMPRESSION PROCEDURE

The gingival trough is packed with Gingi-Pak string using a McEwen packer. Raphon solution is flooded on top of the string and is left for approximately 4 minutes to control gingival bleeding. If oozing continues after removal of the string, dentoelectric cautery can be used to coagulate the tissue, being careful not to touch bone or leave it exposed. A Hyfrecator with a gingival needle is used.

A check-bite tray is tried for clearance and filled with hydrocolloid, and a hydrocolloid impression is made (Fig. 4). The check-bite tray is used best with its own tubing assembly because a direct flow of water through the small lumen of the tray causes the tubing to pop off and spray the patient. A check-bite tray performs three functions: (1) it makes accurate impressions of the abutment teeth and the edentulous ridge, (2) it makes an accurate impression of the opposing teeth, and (3) it makes an adequate interocclusal registration, much superiorly to a wax record.

Kerr hydrocolloid syringes are filled with Surgident stick hydrocolloid, and Surgident Jr. material is placed in the tray. A Hanau conditioner prepares the

hydrocolloid material. The string is removed, and after the syringe material is injected around the preparation, the check-bite tray is inserted and the patient is instructed to close the teeth in the natural position. Cold tap water is circulated for 5 minutes through the tray. The patient is told to open the mouth with a quick snap, and the impression is removed. The impression is placed in a control solution from a minimum of 20 minutes to a maximum of 30 minutes. A Gray laboratory timer at the chair is set for each timed phase of the procedure.

### TEMPORARY CROWN PROCEDURE

The silicone impression is prepared for acrylic resin by cutting sluiceways in the silicone with a pair of manicure scissors. Mer-Don liquid is placed in the crown

TABLE II. CUTTING PROCEDURES*

| INSTRUMENT | USE | FREQUENCY METER AVERAGE | IDLE SPEEDS (R.P.M.) |
|---|---|---|---|
| Page-Chayes | Interproximal cuts | No. 558 at 138,000 r.p.m. | 156,000 |
| | Occlusal cuts | No. 558 at 144,000 r.p.m. | 156,000 |
| | Buccal and lingual cuts | No. 558 at 144,000 r.p.m. | 156,000 |
| Densco air turbines | Chamfering, contours, and opposite cusp reduction | Star stone P21L at 312,000 r.p.m. | 372,000 |
| Page-Chayes | Gingivectomy | No. 1½ Rode at 80,000 r.p.m. | 80,000 |
| Midwest | Finishing | Densco stone F1A at 150,000 r.p.m. | 196,000 |
| | Trimming acrylic resin | No. 171 at 240,000 r.p.m. | 252,000 |

Revolutions per minute when cutting depend upon:
- Torque of handpiece
- Size of cutting tool
- Free-running or idle speed
- Touch used

Brush technique when cutting causes less fluctuation in revolutions per minute
Belt-driven ultra-speed contra-angle instrument causes less speed fluctuation than air turbines

*All instruments, 2- to 4-ounce touch. All turbines, 30 p.s.i. Variable foot control not used for tests.

impressions and Mer-Don powder is sprinkled and mixed into the liquid. A 2-minute set makes the material tacky. The preparations are coated with petroleum jelly, and the tray is seated to position and held and chilled with cold water for 6 minutes. The tray is removed and the formed acrylic resin crowns are removed from the silicone impression. The excess resin is removed with a No. 171 bur in a Midwest air turbine at 30 p.s.i. The speed recorded on the frequency meter is seen in Table II.

The temporary crowns are cemented on the prepared teeth with Opotow temporary zinc oxide and eugenol cement. The excess cement is removed with the Cavitron prophylaxis tip P1. A shade is selected and the patient is dismissed.

### OFFICE LABORATORY PROCEDURES

Vel-Mix stone, mixed with a Whip-Mix vacuum mixing device, is used to pour the casts (Fig. 5). The side with the preparations is poured first and allowed to set for 30 minutes; then the opposing side is poured. The preparation side is set in a Die-Lok tray with artificial stone and then mounted on an articulator. After 1 hour the casts are separated from the impressions and the preparation side is separated from the Die-Lok tray and placed under a 100-watt light bulb for 1 hour.

### HIGH-SPEED LABORATORY PROCEDURES

Places on the casts to be cut and separated are outlined in pencil. The first cuts are made with a diamond saw at a shaft speed of 20,000 r.p.m. in a ball-bearing handpiece mounted on a laboratory motor with a large pulley on the spindle. These cuts do not go all the way through the cast. The separation cuts are made using a jewelers saw, size 000.

The individual dies are trimmed roughly with a Leff type of diamond stone at around 20,000 r.p.m. shaft speed. A stream of air from a Hanau Thermex clip attached to the straight handpiece keeps the field clear of stone debris. Then, the dies are "ditched" with a No. 4 bur rotating at approximately 100,000 r.p.m. in a Sandri straight air-turbine handpiece (Fig. 6). Hand trimming can be done with a sharp Exacto knife. The margins where the castings are to terminate on the dies are outlined with a sharp black pencil. The mounted casts are sent to the laboratory with the appropriate instructions.

### FITTING AND CEMENTATION PROCEDURES

The fixed partial denture is tried in the mouth in its entirety, not fitted unit by unit. The occlusion is adjusted by using a strip of Aluwax softened in water at 120° F. The wax is placed over the restoration and the patient is asked to close the teeth in centric occlusion. The deflective occlusal contacts which show through the wax are marked with a wet indelible pencil. The wax is removed and these spots are reduced with a No. 19 Carborundum stone revolving at about 100,000 r.p.m. mounted in a Page-Chayes contra-angle handpiece. When the occlusion is comfortable, the denture is examined roentgenographically for overhang, then hand polished with paper disks, rubber wheels, and finished burs using speeds up to 4,000 r.p.m.

The prepared teeth are dried with cotton rolls and high velocity suction, cleaned with Hydrexol (a solvent for removing oily residues), and ionized with a 1 per cent sodium fluoride solution using a brush ionizer. This is followed by coating with a light film of liquid Pulpdent. Again the teeth are dried and the fixed partial denture components are wiped inside and out with the solvent.

A Kile slab which has been set in room-temperature water is dried and placed in front of a fan or air conditioner outlet for 3 minutes. The Kile system of measurement of cement and liquid is used (Fig. 7). Two capsules of cement are emptied on the Kile slab and two portions of liquid are ejected from the liquid measuring device for two full-crown abutments.[3]

The Kile arrangement offsets the error of approximating the proportions of liquid and powder and eliminates moisture from the cement powder and evaporation of the liquid. This system cuts down on mixing time and, if used properly, guarantees an excellent, hard set.

Fig. 4. Fig. 5.

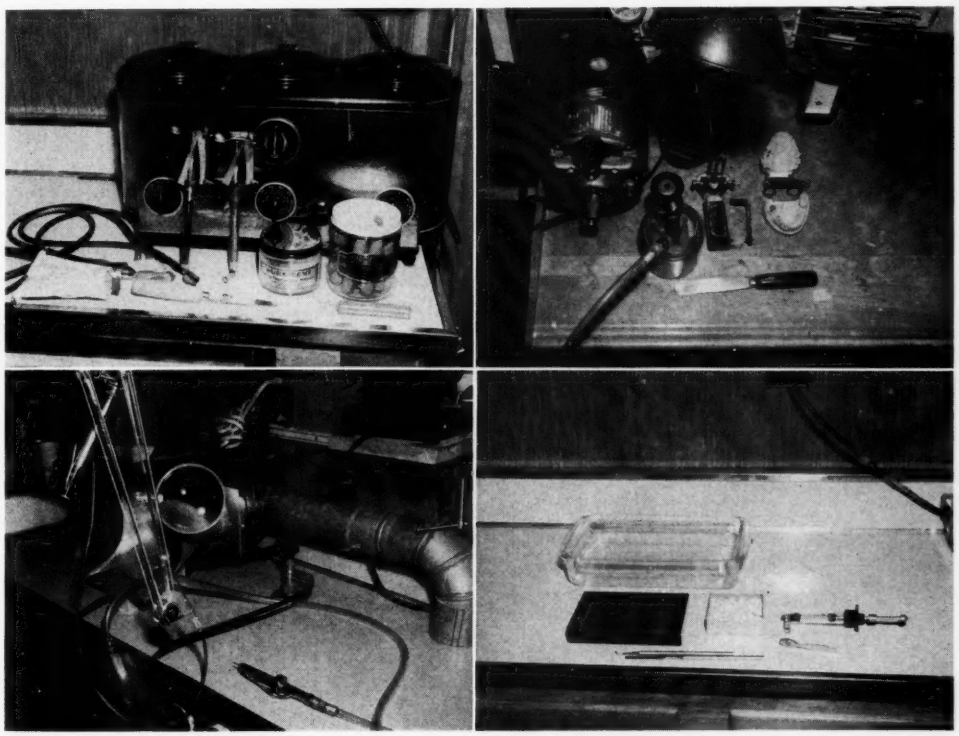


Fig. 6. Fig. 7.

Fig. 4.—The Hanau hydrocolloid conditioner is in the background. Kerr hydrocolloid syringes, Surgident inlay sticks, and Surgident Jr. material are used for making the impression in the Coe check-bite tray. Justi silicone impression material is used for making the preliminary impressions.

Fig. 5.—Whip-Mix vacuum investing outfit and Die-Lok tray.

Fig. 6.—High-speed laboratory handpieces. A laboratory engine is equipped with a Chayes high-speed Formica pulley to develop 30,000 r.p.m. at the straight Emesco ball-bearing handpiece. Note the air stream attachment on the straight handpiece. A Sandri straight air turbine handpiece on the bench furnishes power for "ditching" dies.

Fig. 7.—The Kile cementation assembly consists of a Pyrex dish of cold water, black Kile mixing slab, cement powder in capsules, cement-measuring ejector syringe, and Med-Arts inlay bite instrument.

The entire amount of powder and liquid is mixed together for 1 minute and then placed into the crowns. The crowns are seated with a McShirley electric mallet using a metal tip at the highest frequency and stroke. The patient is instructed to close the teeth on a Med-Arts inlay holder for 5 minutes. The excess cement is

removed with a Cavitron prophylaxis tip P1. Ultra speed is brought into play once more by spinning the margins with a P46 white vitreous enamel Chayes stone at 60,000 to 80,000 r.p.m. in a Page-Chayes instrument.

### PATIENT COMFORT AIDS

The area to be treated is anesthetized locally using a 30-gauge needle. The patient is draped with an apron and towel to prevent water soiling and is made comfortable in a contour chair.

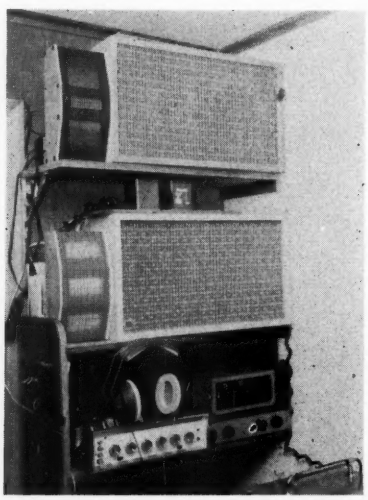


Fig. 8.—A stereo assembly of six matched speakers, dual amplifier, and tuner. Stereo earphones are placed on the back of the patient's head.

The contour chair position takes advantage of the rest curve which has been built in to the Ritter Euphorian chair. Several other chairs of this type have been used and all were overwhelmingly appreciated by patients. A small percentage, about ten out of more than five hundred, did not like the contour chair. One woman stated that the position was unacceptable to her. A full-drape apron covering her from chin to feet helped her to accept the rest curve position. Small children are treated easily because of a contour inset placed in the Euphorian chair. Patients over 6 feet 4 inches tall found the head rest too low. One of the best features of the contour rest curve is that it lessens the patients' tendency to slump. This cuts down on operating light adjustments, and because the patient has nothing to shove with his feet, head and body movements are lessened. Patients usually are more relaxed. Many even fall asleep when cutting procedures are being carried out in the mouth.

The most outstanding disadvantage of the rest curve type of chair is to the dentist who does not work sitting down. The contour chair can be used almost as

well as the standard chair when the dentist is standing, but the patient has to be brought forward, so that the full advantage of the rest curve is not used. Some find that the chair does not go low enough for some patients when the dentist is in sitting position.

Modification of some units is desirable. Ritter G and H units can be raised about 4 inches with a special base to prevent the bracket table arm from being in the way of some patients' feet. Some dentists who work from behind the chair find that the air, water, and mouth spray syringes and belt engine positions are not easily accessible in a few positions. Placing the chair base as far forward as possible will help this situation.

Reaching the cuspidor from the rest curve position is difficult. A high velocity aspirator is desirable, but a saliva ejector placed in the mouth for all procedures, even prophylaxis, reduces the need for the use of the cuspidor.

Some patients with throat conditions, such as a heavy postnasal drip, were questioned about the rest curve position with the head back. Most said that they felt more comfortable than with the head forward. Impressions can also be made in the contour position.

Golden[4] observed that, "Contrary to common opinion, performance is not jeopardized when the patient is leaning back in comfort." The dentist who takes the time to adjust himself and his technique to the rest curve chair will find it a definite asset to general practice.

Music is another comfort aid to patients. Hi-fidelity and stereophonic music can be a great aid in keeping patients at ease (Fig. 8). Stereophonic music played through appropriate speakers or stereo earphones is being used. A few patients do not accept music and are irritated by it. Gardner[5] reports success in using a specially

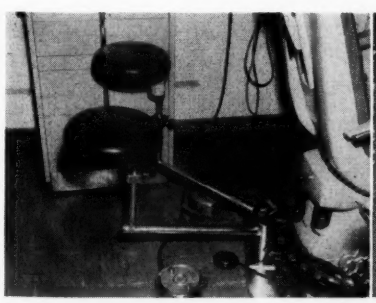


Fig. 9.

Fig. 10.

Fig. 11.

Fig. 9.—Castle T & M twin operating stools are used by the dentist and his assistant.

Fig. 10.—Variable foot controls. At the left, the unit engine control; in the middle, the Encore Jr. for air turbines; at the right, the Densco Vario-Tek for the air turbine.

Fig. 11.—The use of the Encore Sr. variable foot control eliminates some air-turbine control boxes.

designed audio system through earphones and specially prepared stereo tapes with a background noise. All audible sound is patient controlled. However, earphones sometimes get in the dentist's way.

DENTIST AIDS

The dentist and chair assistant sit at the head of the patient (Fig. 9). An auxiliary cabinet to the rear of the chair helps the dentist and assistant by making instruments available to both.

The assistant's index finger is used to retract the tongue, while the other hand maneuvers the high velocity suction mouthpiece which supplements the Hydroceptor tubing. Most patients can be prevented from using the cuspidor by this procedure. The dentist's index finger or mouth mirror is used to retract the buccal tissues.

The air mirror is used where water spray complicates the vision. A heavy stream of air blowing over the face of the mirror is desirable. The mirror should be dipped in a detergent solution. Mirrors can be cleaned by turning the handpiece spray so that it washes the reflective surface.

The variable foot control is desirable when using the air turbines (Fig. 10). Some contain all the controls necessary to run an air turbine without using a unit control box (Fig. 11). Others work through the unit control box. The Ritter J unit incorporates an ideal arrangement of variable foot control coupled with the unit engine control. No "switching" is necessary when changing from one to the other, and the foot control operates from right to left and is not a treadle type.

Advantages of the variable foot control are: (1) instantaneous speed variations are possible, (2) air turbines may be started with a more quiet sound which does not startle the patient, (3) all controls can be regulated with the foot, (4) unit control boxes can be eliminated, and (5) clicking of solenoids with one type can also be eliminated. The disadvantages are: (1) most variable controls are of the treadle type which can cause foot fatigue and (2) another foot control on the floor makes one more item to clutter up floor space. On the whole, the advantages outweigh the disadvantages.

SUMMARY

The actual shaft speed of high- and ultra-speed cutting tools was measured by an electronic device while they were used in the mouth in the preparation of teeth for a fixed partial denture. High-speed procedures for laboratory work were presented. Auxiliary aids to the patient and dentist were discussed and evaluated.

CONCLUSION

Use of a multiple arrangement of ultra- and high-speed, belt- and turbine-driven equipment along with auxiliary aids results in considerable benefits to both patient and dentist. Reducing trauma and time and making the patient as comfortable as possible during the operation are the principal advantages.

REFERENCES

1. McKay, Robert C.: Evolution of Tooth Cutting Techniques and Its Influence on Restorative Dentistry, J. Pros. Den. **8**:843-853, 1958.
2. Hartley, Jack: Dental Times Report, June 15, 1959, p. 8.

3. Kilpatrick, H. C.: High Speed and Ultra Speed in Dentistry Equipment and Procedures, Philadelphia, 1959, W. B. Saunders Company.
4. Golden, S. S.: Human Factors Applied to Study of Dentist and Patient in Dental Environment: A Static Appraisal, J.A.D.A. **59**:26, 1959.
5. Gardner, Wallace: Personal Communication.

Box 119A
Smith Ridge Rd.
New Canaan, Conn.

---

## To Restore Plasticity to Calcium Hydroxide Paste

The commercial brand of methylcellulose calcium hydroxide paste may become powdery and useless after only a small portion has been used. To restore plasticity to the remaining portion in the tube, inject a few drops of either sterile distilled water with a Luer syringe or anesthetic solution with the conventional dental syringe.

The newly injected liquid and calcium hydroxide paste can be homogenized suitably by palpation of the tube.

H. J. Ralkowski, D.D.S.
*Bremerton, Wash.*

# A NEW VIBRATOR FOR AMALGAM CONDENSATION AND REMOVAL OF CALCULUS

SAM KARLSTRÖM, ODONT. DR.
*Gävle, Sweden*

THE AIM IN THE CONDENSATION OF AMALGAM is to pack the amalgam crystals closely together so that the minimum amount of mercury is required for cohesion. The amalgam must retain its plastic properties so that it can be worked easily.

Similar conditions apply in the modern concrete industry. The solid particles are compactly arranged so as to obtain a product with the greatest possible density, compactness, strength, and hardness with the minimum dimensional changes.

## VIBRATION METHOD

The "stamping method" was used in the concrete industry until 1917. By this method, the strength and homogeneity of the material are increased by subjecting it to a series of blows (stamping). The same year, the French engineer E. Freyssinet introduced a completely new method of making concrete—the "vibration method." This method constituted a revolution in that field and is now used to the exclusion of all others.

Freyssinet's method involves the use of mechanical equipment to produce rapid vibration in the recently stirred concrete. Through the kinetic energy thus supplied, the solid particles in the mass are subjected to forces that reduce the static friction between them and set them in motion. The particles execute soft, elastic oscillations and are regrouped so that there is the minimum of space between them.

The characteristic of these forces is that they are not applied as blows but as soft, elastic, sine curve oscillations. In fact, the force may be regarded as a tone that penetrates the concrete at a certain velocity.

The principles applied in the amalgam technique are those followed in the concrete industry before the time of Freyssinet. The condensation is effected by applying the greatest possible mechanical pressure; to increase the effect, use is made of automatic mallets which rely chiefly on impulse action.

Clearly, this treatment of subjecting amalgam to impulses cannot be called a true vibration. Therefore, the same effect cannot be achieved.

## INKA INTRAORAL VIBRATOR

The Inka intraoral vibrator is an amalgam condenser that is designed according to the principles used by Freyssinet. This instrument is a further development of the vibrators described previously.[1]

The moving components of the instrument (Fig. 1) are enclosed in a cylindric steel casing (*1*). One end of the casing is open and designed for connection directly to the dental engine. The other end, the vibrator head (*2*), is closed so that the interchangeable points can be fixed therein.

The vibrations are produced by a rotor (*3*) which consists of a cylindric oscillating rod that rotates about its own axis as a centrifugal pendulum. The free end of the rotor is shaped as a hollow body (*4*) and rolls on a pin (*5*). The pin constitutes the inner part of the vibrator head, which is firmly attached in the cylindric casing. The cylindric rod (*3*) is connected to the driving shaft of the dental engine (*6*) by means of an elastic coupling (*7*). The coupling is arranged to allow free

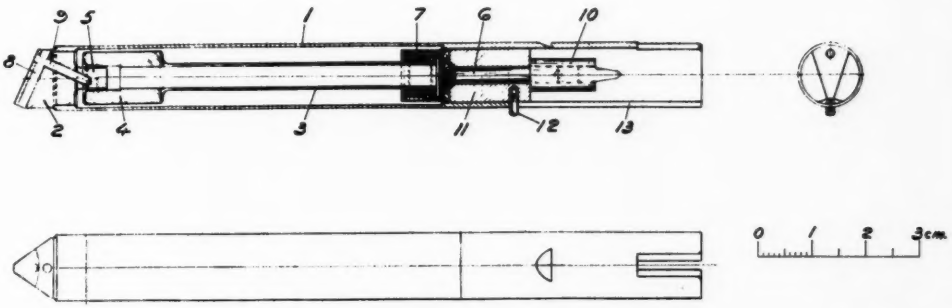



Fig. 1.—A schematic diagram of the Inka intraoral vibrator showing the internal components.

oscillation of the rotor in relation to the driving shaft. The rod cannot rotate independently of the shaft. The coupling consists of a rubber sleeve inserted between the end of the driving shaft and the rotor, which overlap one another.

The vibrator head is provided with two channels (*8, 9*), drilled at different angles, which take the points. One channel makes an angle of 25 degrees with the axis of the vibrator, and the other is perpendicular to the former. Since one of the channels passes through the head, it is possible to insert the points from either end. Thus, there are three positions for the point, one of which makes an angle of 65 degrees backward with the axis of the vibrator. The points are shaped differently according to the purpose for which they are intended, for instance, a spatula, a chisel, a knife, a disc, a tenon, and a spherical body (Fig. 2).

The shaft of the point, the diameter of which is slightly less than that of the channel, is flexible and slightly curved. When the shaft is pushed into the channel, it is held firmly by friction in any desired position.

The rotor and the driving shaft, which are connected to the dental engine by a claw coupling (Fig. 1, *10*), have their bearing in the cylindric casing by means of a piston (*11*). A fixed pin (*12*) in the piston passes out through a longitudinal slit (*13*) in the casing. The pin permits the rotor with the piston and the driving shaft to be withdrawn from the casing for inspection or change of the rotor.

For practical reasons, the number of rotors at present is limited to two—a light one used for vibration of amalgam and the other, a heavier one, intended chiefly

for removal of dental calculus. The higher amplitude of the heavier rotor gives a greater penetrating effect. Therefore, with the aid of a chisel or knife-shaped, slightly convex point, calculus can be more effectively scaled from the surfaces of teeth.

### CLEANING THE VIBRATOR

If the surfaces of the hollow body (Fig. 1, *4*) and the pin (*5*) become contaminated with oil, slipping will occur and the efficiency of the instrument will be reduced. The surfaces must be kept clean with a grease solvent such as chloroform, ether, or trichloroethylene (benzine is unsuitable).

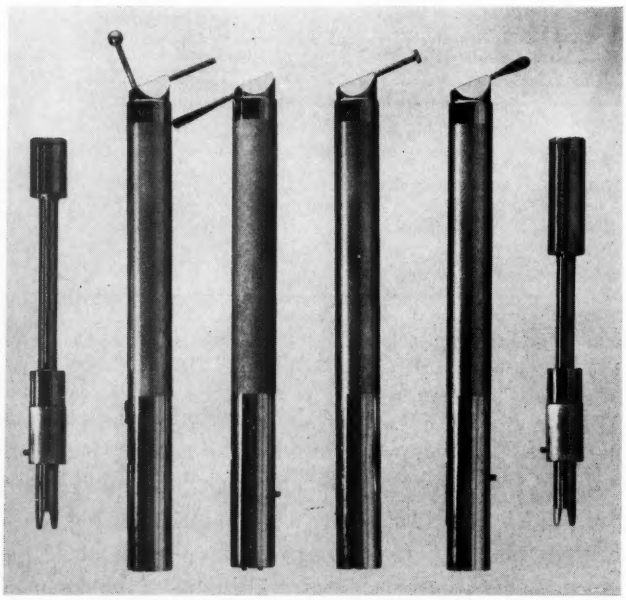


Fig. 2.—The Inka intraoral vibrator has various types of points and two rotors. The light rotor is used for the condensation of amalgam. The heavier rotor, with greater amplitude and penetrance, is intended chiefly for the removal of dental calculus.

For the vibrator to work at the maximum efficiency, it should be cleaned regularly at short intervals, especially when it is new. This is particularly true if the apparatus becomes warm during use.

A specially designed instrument known as the cleaning rod is used to facilitate the cleaning operation. This rod has the form of a solid aluminum cylinder but is somewhat longer than the vibrator casing (*1*), into which the rod can be inserted by virtue of its smaller diameter. One end of the cylinder is drilled out to a depth of about 1 cm. and threaded. The diameter is sufficiently large for the end of the rod to pass loosely over the pin (*5*) when the rod is inserted into the vibrator casing.

To clean the vibrator, a plug of cotton wool dipped in the cleansing fluid is inserted into the casing. Then, the rod is inserted into the casing so that it presses

the cotton wool around the pin (*5*). The pin is cleaned by turning the rod *clockwise*. The cotton wool catches in the threads and accompanies the rod as it is removed when the cleaning operation is complete. The process may be repeated several times as required.

The other end of the aluminum rod is shaped as a threaded pin, which is used for cleaning the hollow body (*4*) that rolls on the pin (*5*). The same procedure as described is followed.

The vibrator described is designed for connection to a slip joint. In order that the vibrator may be used also with the Doriot straight handpiece, some modifications of the design have been made. The resulting instrument is only about one-half as long as the one for the slip joint. This shorter instrument is connected

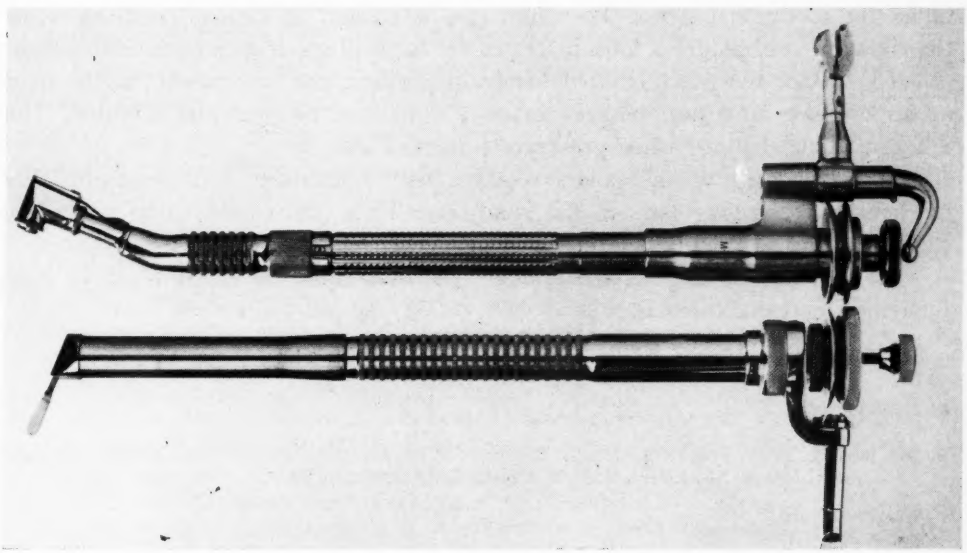


Fig. 3.—Two Doriot straight handpieces, one with the intraoral vibrator and the other with the standard contra-angle handpiece.

to the Doriot straight handpiece in the same way as the contra-angle handpiece. The total length of the Doriot handpiece with vibrator will then be slightly less than the total length of the Doriot straight handpiece with contra-angle handpiece (Fig. 3). A pair of tweezers and a plug of cotton wool dipped in the cleansing fluid are used to clean this instrument.

## ADVANTAGES OF THE INKA VIBRATOR

The Inka intraoral vibrator has many advantages.

(1) It provides soft, elastic, sine curve vibrations. The tone that is sent through the amalgam has a penetrating effect so that the entire mass is affected. The efficiency is increased also, because the instrument gives a frequency several

times greater than is obtainable with other amalgam condensers. Experiments have shown that the soft vibration provided by the Inka intraoral instrument is better tolerated, especially by children, than the percussion effect.

(2) Pressure is not necessary for the amalgam mass to be affected by the instrument. It suffices for the vibrator point to come into contact with the amalgam for it to melt, just as when a warm instrument is brought into contact with a wax surface. Therefore, there is no risk of the amalgam of a contour filling being expelled from the cavity by a pressure applied during condensation.

(3) The points used for the condensation of the amalgam may be placed in the vibrator in three directions. The instrument may, therefore, be used easily in any situation that may arise in the mouth. The number of points required also is kept to a minimum.

(4) The point is rotatable about its axis and remains firmly in position even under the vibrational stress. The point can be rotated in various positions while the vibration is in progress. This increases the range of application of the instrument.

(5) Since the point is fixed firmly in position, the instrument can be used as an ordinary amalgam plugger or as a combined plugger and vibrator. The vibrator is not damped when pressure is exerted with it.

(6) Changing of the points requires only a moment and is considerably quicker than changing burs in the handpiece. Thus, the condensation procedure can be performed rapidly before the amalgam has hardened.

(7) When the larger rotor is fitted, the Inka intraoral vibrator can be used for removing dental calculus.

(8) The vibrator casing is easily sterilized by the usual procedures.

REFERENCE

1. Karlström, Sam: The Pontostructor Method for the Construction of Fixed Bridges, Crowns and Inlays, Stockholm, 1955, Nordiska Bokhandeln, p. 73.

NYGATAN 37
GÄVLE, SWEDEN

## *MISCELLANEOUS*

# CARE OF DENTURES

LOUIS M. FLEISCH, D.D.S.
*Topeka, Kan.*

ONE OF THE STATEMENTS in the progress report of the Committee on Principles, Concepts, and Practices[1] suggests, "Cleaning procedures and denture care should be demonstrated and explained to the patient receiving new dentures." I routinely give my denture patients a copy of the American Dental Association's booklet, *Your Artificial Dentures,* a denture brush, and a copy of the following printed instructions:

CARE OF YOUR DENTURES

Before cleaning your dentures fill the wash basin with water. If you should drop them, the water will break the fall, minimizing the danger of breakage. Clean your dentures at least once a day using a brush and facial soap.

Do *not* use scouring powder or abrasive hand soaps.

Do *not* place your dentures in hot water. Temperatures over 150° may warp them.

Dentures should be sterilized at least once a week. This can be done by placing them in a solution of household bleach (Clorox or Purex).

Use one teaspoon of bleach to one cup of water; soak for 15 minutes.

Do *not* place chrome complete or partial dentures in a bleach solution.

To remove stains and calcium deposits (tartar), soak the dentures in full strength *white* vinegar for 15 minutes. If this is done regularly, stains are easily removed. If not, it may be necessary to leave dentures in vinegar for a longer period.

The vinegar can be used many times if it is stored in an airtight glass or plastic container.

If dentures are left out of the mouth more than 30 minutes, they should be stored in water.

I find that patients appreciate this service. Since I started giving out the printed instructions, I have found that when patients return for adjustments or relining, the dentures are cleaner.

REFERENCE

1. Principles, Concepts, and Practices in Prosthodontics. A Progress Report. The Academy of Denture Prosthetics, J. PROS. DEN. **9**:528, 1959.

303 NATIONAL RESERVE BLDG.
TOPEKA, KAN.

# *READERS' ROUND TABLE*

MILWAUKEE, WIS.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

In connection with the publication of the article, "Balkwill's Angle for Complete Dentures," by Finn Tengs Christensen in the last issue of the JOURNAL OF PROSTHETIC DENTISTRY [J. Pros. Den. 10:95-98, 1960], I should like to call to your attention a source of error in this article.

Dr. Tengs Christensen is using the sign ÷ in several expressions. In Norway, as in other Scandinavian countries, this sign is a *minus* sign *not* a division sign. The division sign is merely a colon. $\beta \div \phi$ means beta minus phi, but I am afraid that American dentists and students would read it beta divided by phi. This would be written $\beta : \phi$ or $\beta / \phi$ in the Scandinavian languages.

I might suggest that you call this to the attention of the readers of the JOURNAL. Even if you may not find it important enough for special mentioning, I thought that I would at least call it to *your* attention so that you may be aware of this peculiar difference between the use of these signs here and in the countries mentioned and so that future errors of this nature may be avoided.

Sincerely yours,

GUNNAR RYGE, D.D.S., M.S.

# *BOOK REVIEWS*

LOCAL ANESTHESIA AND PAIN CONTROL IN DENTAL PRACTICE. By Leonard M. Monheim, B.S., M.S., D.D.S., St. Louis, 1957, The C. V. Mosby Company. Pp. 299, illustrated, indexed. Price $8.75.

The purpose of this book is to provide a guide for the control of pain in dentistry by practical use of scientific information relating to pre- and postoperative medication, local anesthesia, and vasoconstrictors. The all-inclusiveness of this well-organized, well-illustrated, comprehensive coverage of all the aspects of pain control in dentistry has never before been achieved. All chapters are invaluable for the dental student and the dental practitioner. Especially valuable are chapters one, six, ten, and twelve, which are concerned with pain perception, pain reaction, pain threshold, pain pathways, and the control of pain, which have been written about too infrequently. Concise, practical considerations of the anatomy of the head and neck, techniques of regional anesthesia for the head and neck, physical and chemical properties of local anesthetic solutions and vasoconstrictors, preanesthetic evaluation and choice of anesthetic, sterilization techniques, and interesting, valuable, medico-legal aspects of regional anesthesia make this the most satisfactory text on local anesthesia for the dental student and dental practitioner alike. My opinion is that this book is accurate, complete, and understandable and that it is necessary as a part of the office equipment of all dentists who make injections of local anesthetics.

Morgan L. Allison, D.D.S.

PRECISION WORK FOR PARTIAL DENTURES. By Alfred A. Steiger, D.D.S., and Raoul H. Boitel, Dr. Med. Dent., D.D.S., Zurich, 1959, Buchdrukerei Berichthaus. Pp. 229, illustrated, indexed. Price $16.50. (United States source: Swiss Dentistry Distributors, 2110 Central Park, Evanston, Ill.)

This book was written to supply the meticulous dentist and the dental technician with detailed technical instruction for the construction of various types of stress breakers and internal attachments to be used in conjunction with partial denture retention and function. The book is well written and profusely illustrated. The quality of the printing and binding is excellent.

Starting with early, handmade attachments, some fifteen different designs are described and illustrated as the history of the development of this type of retainer is unfolded. The type of internal attachment described in its various forms throughout the book is a channel-shoulder-pin design that can be made to conform to almost any situation involving the problem of retention for a partial denture.

Careful diagnosis, complete cooperation between dentist and technician, and thorough knowledge of laboratory procedure by the dentist permeate the entire text. A philosophy of cavity preparation is included by means of illustrations and description. Various mechanical aids not usually found in dental offices are shown, such as screw threading instruments, the

Planostat, the Paralleloform, and the Parallelometer Bochmann, with its many attachments to survey, drill parallel holes, mill parallel surfaces, and perform a host of other procedures. Most of the instruments described are now available in this country through the source of this book.

Impression techniques for individual teeth and for working casts are described in detail leading to a step by step description of the construction of the channel-shoulder-pin attachment. The principle of broken stress for the free end partial denture base is thoroughly discussed, with many ways of accomplishment described. Practical restorations are shown, including all of the steps of procedure.

This book is strictly a graduate study in partial denture prosthodontics and in the opinion of the reviewer could well change the entire concept of partial denture construction in this country.

Bertram H. Downs, D.D.S.

# *NEWS AND NOTES*

## MEETINGS

Greater New York Academy of Prosthodontics, Wykagyl Country Club, Westchester, N. Y., June 3, 1960.

Academy of Denture Prosthetics, La Concha Hotel, San Juan, Puerto Rico, June 19 to 24, 1960.

American Dental Society of Europe, Edinburgh, Scotland, July 5 to 8, 1960.

Indonesian Dental Association, Bandung, Indonesia, during July, 1960. For further information write to Dr. R. M. Soelarko, Congress Secretary, Indonesian Dental Association, 55 Riaustreet, Bandung, Indonesia.

Pacific Coast Society of Prosthodontists, Miramar Hotel, Santa Monica, Calif., Aug. 4 to 6, 1960.

Swedish Dental Society, Centennial Meeting, Stockholm's Concert Hall and Apollonia, Stockholm, Sweden, Aug. 17 to 20, 1960. For further information write to Torsten Telander, Secretary, Swedish Dental Society, Nybrogatan 53, Stockholm Ö, Sweden.

Fourth National Cancer Conference sponsored by the American Cancer Society, National Cancer Institute, Minneapolis, Minn., Sept. 13 to 15, 1960. The theme of the conference is "Changing Concepts Concerning Cancer." For further information write to the American Cancer Society, Inc., Medical Affairs Dept., 521 West 57th St., New York 19, N. Y.

Canadian Dental Association, Ottawa, Canada, Sept. 25 to 28, 1960.

American Society of Oral Surgeons, Westward Ho Hotel, Phoenix, Ariz., Oct. 12 to 15, 1960. For further information write to Mr. D. C. Trexler, Executive Secretary, 840 North Lake Shore Dr., Chicago 11, Ill.

American Denture Society, Beverly Hilton Hotel, Los Angeles, Calif., Oct. 14 and 15, 1960.

Greater New York Dental Meeting, Statler Hilton Hotel, New York, N. Y., Dec. 5 to 9, 1960. For further information write to Mrs. Mabel Purdy, Executive Secretary of the Meeting, Room 106A, Statler Hilton Hotel, New York 1, N. Y.

---

Dentists from the States of Washington, Oregon, California, Montana, Nevada, Idaho, Utah, Arizona, Alaska, and Hawaii and from the Canadian Provinces of Alberta and British Columbia are invited to attend the Eleventh Triennial Pacific Coast Dental Conference in Portland, Ore., July 10 to 14, 1960. Dentists in other parts of the country planning to be in the Northwest during this period and wishing to attend this conference may obtain further information and application for registration from Dr. Kenneth R. Jensen, 1033 Southwest Yamhill St., Portland 5, Ore.

## ANNOUNCEMENTS

The supply of copies of the first edition of the *Glossary of Prosthodontic Terms* has been exhausted. Copies of the second edition will be available by Sept. 1, 1960. Glossaries will be supplied to those whose orders have been received as soon as they are available.

---

Reprints of "Principles, Concepts, and Practices in Prosthodontics" may be obtained by writing Dr. W. Les Warburton, Secretary-Treasurer, Academy of Denture Prosthetics, 807 Medical Arts Bldg., Salt Lake City 11, Utah. The price is 25 cents per copy, with a 20 per cent discount allowed on purchases of 20 or more copies. Cash, check, or purchase order *must* accompany the order.

---

BOOKLET ON DENTAL MATERIALS

Up-to-date information on amalgam, burs, mercury, impression compounds, silicate cements, acrylic resins, casting alloys, and other commonly used dental materials is now available in the 1960-1961 edition of *ADA Specifications for Dental Materials.*

The booklet, prepared by the ADA Research Division, National Bureau of Standards, includes the latest revised brand name list of Certified Dental Materials. Information on *why* a dentist should use a certified material, and how material is tested to meet ADA specifications, is also included in the 84-page booklet.

The booklet also lists ten motion pictures that have been developed showing how research on dental materials and instruments can be applied in everyday practice. These films make excellent presentations for dental society or study club meetings.

In addition, there is a bibliography of publications on dental research conducted at the National Bureau of Standards with a classification index for each type of material or instrument that has been investigated or developed. Available reprints are listed.

*ADA Specifications for Dental Materials* is available at $2.25 per copy from the Order Department, Desk 462, American Dental Association, 222 East Superior St., Chicago 11, Ill.

---

"Artificial Dentures—A Health Service or a Health Hazard" is the title of a new leaflet published by the American Dental Association, Bureau of Dental Health Education. The leaflet explains to the public that artificial dentures can be a health service for those who have the advantage of professional attention from a dentist, or a health hazard for those who attempt to get denture services from nonprofessional sources. The leaflet discusses the education of a dentist and, in some detail, the many factors he takes into consideration in preparing dentures for a patient. It points out that those persons other than dentists who make dentures directly for the public are unqualified and probably are operating in violation of state laws regulating the practice of dentistry.

The leaflet is available from the Order Department, American Dental Association, 222 East Superior St., Chicago 11, Ill., at the following prices: 25 for $.75, 50 for $1.40, 100 for $2.25, 500 for $10.00. The Order Department will give price quotations for larger quantities on request.

---

The Midwest Oral Rehabilitation Study Group has offered a $100.00 prize to the University of Illinois, College of Dentistry, to be known as the Stanley D. Tylman Award.

This prize is to be awarded to the graduating senior student who, in his clinical performance, has demonstrated an understanding and application of the principles of functional occlusion in oral rehabilitation of a clinical patient.

---

By action of the Executive Council of the American Denture Society on Feb. 5, 1959, the Essay Contest for Senior Dental Students will not be held this year.

---

11TH ANNUAL TUFTS BERKSHIRE CONFERENCE

The Eleventh Annual Tufts Berkshire Conference on Periodontology and Oral Pathology will be held June 19 to 23, 1960, at Eastover, a resort hotel in the Berkshire Mountains at Lenox, Mass.

The two major topics for this year's conference are "Medical Aspects of Periodontal Treatment" and "The Attainment of Physiologic Occlusion in the Total Treatment of Periodontal Disease."

The conference curriculum is arranged so that the scientific sessions are held in the morning and evening and the afternoons are open for recreation and informal discussion. The conference is open to general practitioners and individuals in specialized practice.

For further information and application write to 11th Annual Berkshire Conference, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston 11, Mass.

---

FRANCIS B. VEDDER SOCIETY OF CROWN AND BRIDGE PROSTHODONTICS

At the meeting held last November at the Kellogg Auditorium, School of Dentistry, The University of Michigan, Ann Arbor, a postgraduate society dedicated to the study of problems connected with crown and bridge prosthodontics was inaugurated. The society will be known as the Francis B. Vedder Society of Crown and Bridge Prosthodontics, in honor of Dr. Vedder, professor and chairman of the Crown and Bridge Department, School of Dentistry, The University of Michigan.

The objective of the society will be "to promote and encourage advancement of sound restorative principles in the practice of crown and bridge prosthodontics; to stimulate and be informed of and to advance the latest developments, theories, techniques, and research in crown and bridge; to exchange ideas and promote coordination with allied departments of dentistry; to promote interchange of knowledge, design and structure of crown and bridge problems, both clinical and laboratory."

---

DENTAL LABORATORY TECHNOLOGY COURSE

The Ohio State University, College of Dentistry, announces that it is receiving applications of students for the Curriculum of Dental Laboratory Technology. This course of study of the laboratory phases of prosthodontics extends over 2 academic years and leads to a Certificate of Graduate Dental Laboratory Technologist.

Application forms may be obtained by writing to the Entrance Board, The Ohio State University, Administration Bldg., 190 North Oval Dr., Columbus 10, Ohio. Applications should be received by the Entrance Board by Aug. 1, 1960, for admission to the class starting Sept. 26, 1960.

For further information write to the Chairman of Dental Laboratory Technology, The Ohio State University, College of Dentistry, 305 West Twelfth Ave., Columbus 10, Ohio.

---

RESEARCH AND TEACHING TRAINEESHIPS

Research and Teaching Traineeships suported by the U. S. Public Health Service in the biologic sciences and in the comprehensive treatment and rehabilitation of the cleft palate patient are available at the University of Pennsylvania, School of Dentistry. Candidates for the traineeships in the biologic sciences must qualify for admission to the Graduate School of Arts and Sciences. These traineeships lead to M.S. or Ph.D. degrees.

The traineeship in the comprehensive treatment and rehabilitation of the cleft palate patient is clinically oriented; however, opportunities for course work in fields related to cleft palate therapy are available. If the trainee can qualify for graduate credit in the Graduate School of Arts and Sciences, course work may be applied toward requirements for M.S. or Ph.D. degrees.

Remuneration will vary depending on the qualifications and needs of the successful candidates. Inquiries should be directed to the Chairman of the Committee on Traineeships and Fellowships, University of Pennsylvania, School of Dentistry, 4001 Spruce St., Philadelphia 4, Pa.

---

DENTAL INTERNSHIP PROGRAM

The Veterans Administration Hospital, Dearborn, Mich., announces that it is accepting applications for its 1-year rotating Dental Internship program which will begin July 1, 1960.

Further information can be obtained by writing the Manager or Chief, Dental Service, Veterans Administration Hospital, Southfield Rd. and West Outer Dr., Dearborn, Mich.

---

GRADUATE PROGRAM IN DENTISTRY AT THE UNIVERSITY OF WASHINGTON

The degree of Master of Science (M.S.D.) is awarded for satisfactory performance in the academic and clinical aspects of the discipline and the submission of a satisfactory thesis reporting on research in basic science. The following courses are available to properly qualified applicants:

Fixed Partial Dentures, K. N. Morrison, D.D.S., M.S. A minimum of three consecutive quarters (9 months) of residence is required for a major. Class limited to three.

Operative Dentistry, Gerald D. Stibbs, B.S., D.M.D. Three quarters (9 months); limited to three.

Oral Pathology, Leo M. Sreebny, A.B., D.D.S., M.S., Ph.D. Eight quarters (24 months); limited to two.

Oral Surgery, John D. Gehrig, D.D.S., M.S.D. Three quarters (9 months) plus 2-year hospital residency, combined academic and hospital work; limited to one.

Orthodontics, Alton W. Moore, D.D.S., M.S. Six quarters (18 months); limited to ten.

Pedodontics, David B. Law, B.S.D., D.D.S. Five quarters (15 months); limited to two.

Periodontics-Endodontics, John I. Ingle, D.D.S., M.S.D. Eight quarters (24 months); limited to five students in Periodontics and three in Endodontics. The course in Periodontics is given by Dr. Saul Schluger.

Prosthodontics, Harry A. Young, D.D.S. Three quarters (9 months); limited to two.

## POSTGRADUATE COURSES

Boston University, School of Medicine, Division of Graduate Studies, Department of Stomatology, announces the following postgraduate courses:

Periodontal Prosthesis, Dr. Leo Talkov, Dr. David J. Baraban, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, and Dr. Gerald M. Kramer, May 16 to 20, 1960.

Surgical Procedures in Periodontal Therapy, Dr. Lewis Fox and associates, May 23 to 27, 1960.

For further information write to Director of Postgraduate Studies, Department of Stomatology, Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.

---

Boston University, School of Medicine, offers 1-year courses in Oral Surgery and Endodontics and courses of 2 academic years in Orthodontics and Prosthodontics.

For further information concerning these courses write to Department of Stomatology, Boston University, School of Medicine, 80 East Concord St., Boston 18, Mass.

---

Indiana University, School of Dentistry announces the following postgraduate courses:

Complete Denture Construction, June 15, 22, and 29, July 6 and 13, 1960.

Partial Denture Design and Construction, July 11 to 14 and on four consecutive Thursdays, June 23 and 30, July 7 and 14, 1960.

Course for Laboratory Technicians on Partial Denture Design and Construction, July 25 to 28, 1960.

For further information and application write to Indiana University, School of Dentistry, 1121 West Michigan St., Indianapolis 2, Ind.

---

The University of North Carolina, School of Dentistry, announces the following postgraduate courses:

Clinical Periodontics and Oral Pathology, June 7 to 11, 1960.

Dentistry for Children, I, II, and III, July 11 to 15, 18 to 22, and 25 to 29, 1960.

For further information and application write to Office of Postgraduate Dental Instruction, School of Dentistry, P. O. Box 750, Chapel Hill, N. C.

---

Northwestern University Dental School announces the following postgraduate course:

Conference for Teachers of Pedodontics, June 6 and 7, 1960.

For further information and application write to Northwestern University Dental School, 311 East Chicago Ave., Chicago 11, Ill.

---

The Ohio State University, College of Dentistry, announces the following postgraduate course:

Dental Drugs in Action, May 19 and 20, 1960.

For further information and application write to Postgraduate Division, College of Dentistry, The Ohio State University, 305 West Twelfth Ave., Columbus 10, Ohio.

---

Temple University School of Dentistry announces the following postgraduate course:

Graduate Orthodontics, Sept. 12, 1960, a 2-year course.

For further information and application write to Dr. Louis Herman, Director of Postgraduate Studies, Temple University School of Dentistry, 3223 North Broad St., Philadelphia 40, Pa.

---

Tufts University School of Dental Medicine announces the following postgraduate courses:

A Special Postgraduate Refresher Course in the Diagnosis and Treatment of Pain and Other Symptoms Arising From Temporomandibular Joint Disturbances, May 24 and 25, 1960.

Complete Denture Prosthesis, June 6 to 10, 1960.

Applications are now being accepted for two Research Fellowships in Oral Pathology and Periodontology for the school year beginning September, 1960.

For further information and application write to Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

---

Western Reserve University, School of Dentistry, announces the following postgraduate course:

Periodontics, June 2 to 4, 1960.

For further information and application write to Director of Postgraduate Education, School of Dentistry, Western Reserve University, 2165 Adelbert Rd., Cleveland 6, Ohio.

## DIRECTORY

OFFICERS OF THE ORGANIZATIONS WHICH HAVE THE JOURNAL OF PROSTHETIC DENTISTRY AS THEIR OFFICIAL PUBLICATION

### THE ACADEMY OF DENTURE PROSTHETICS

*President:* Harold L. Harris, 1325 East 16th Ave., Denver, Colo.
*President-Elect:* A. W. Sears, 2705 Atlantic Blvd., Jacksonville 7, Fla.
*Vice President:* Arthur H. Schmidt, University of Puerto Rico, School of Dentistry, San Juan 22, Puerto Rico.
*Secretary-Treasurer:* W. Les Warburton, 807 Medical Arts Bldg., Salt Lake City 11, Utah.
*Associate Editor:* Vincent R. Trapozzano, 3900 Central Ave., St. Petersburg 11, Fla.
Next Meeting: La Concha Hotel, San Juan, Puerto Rico, June 19 to 24, 1960.

### THE AMERICAN DENTURE SOCIETY

*President:* Lindsey D. Pankey, 152 Alhambra Circle, Coral Gables, Fla.
*President-Elect:* LaMar W. Harris, 25 East Washington St., Chicago 2, Ill.
*Vice President:* Homer C. Vaughan, 608 Fifth Ave., New York 20, N. Y.
*Secretary-Treasurer:* Victor L. Steffel, The Ohio State University, College of Dentistry, Columbus 10, Ohio.
*Associate Editor:* Chester Perry, 16350 East Warren Rd., Detroit 24, Mich.
Next Meeting: Beverly Hilton Hotel, Los Angeles, Calif., Oct. 14 and 15, 1960.

### THE PACIFIC COAST SOCIETY OF PROSTHODONTISTS

*President:* Arthur W. Spaulding, 4350 Eleventh Ave., Los Angeles 8, Calif.
*President-Elect:* Arthur E. Aull, 7601 Seville, Huntington Park, Calif.
*Vice President:* Donald A. Forsblade, 610 Professional Bldg., Pasadena 1, Calif.
*Secretary-Treasurer:* Willoughby R. Wright, 2200 Santa Monica Blvd., Santa Monica, Calif.
*Associate Editor:* Roland D. Fisher, 604 South Central Ave., Glendale 4, Calif.
Next Meeting: Miramar Hotel, Santa Monica, Calif., Aug. 4 to 6, 1960.

### THE AMERICAN ACADEMY OF RESTORATIVE DENTISTRY

*President:* Carlisle C. Bastian, 22 Central Park South, New York 19, N. Y.
*President-Elect:* J. Roscoe Tipton, 1203 Medical Arts Bldg., Dallas 1, Texas.
*Secretary-Treasurer:* Morton H. Mortonson, Jr., 735 North Water St., Milwaukee 2, Wis.
*Associate Editor:* George A. Coleman, 235 South Fifteenth St., Philadelphia 2, Pa.
Next Meeting: Conrad Hilton Hotel, Chicago, Ill., Feb. 4 and 5, 1961.

### THE AMERICAN ACADEMY OF CROWN AND BRIDGE PROSTHODONTICS

*President:* William H. Hagen, 821 Medical-Dental Bldg., Seattle 1, Wash.
*President-Elect:* Everett C. Brooks, 4500 Olive St., St. Louis 8, Mo.
*Vice President:* Ray M. Knapp, College of Dentistry, University of Nebraska, Lincoln 8, Neb.
*Secretary:* Willis E. Corry, 2165 Adelbert Rd., Cleveland 6, Ohio.
*Treasurer:* Joseph E. Ewing, 6901 Loretto Ave., Philadelphia 11, Pa.
*Associate Editor:* Stanley D. Tylman, University of Illinois, 808 South Wood St., Chicago 12, Ill.
Next Meeting: Conrad Hilton Hotel, Chicago, Ill., Feb. 4 and 5, 1961.

### THE GREATER NEW YORK ACADEMY OF PROSTHODONTICS

*President:* Gilbert P. Smith, 430 West 116th St., New York, N. Y.
*Vice-President:* Ira E. Klein, 730 West Fifth Ave., New York 19, N. Y.
*Secretary-Treasurer:* Jerome M. Schweitzer, 730 Fifth Ave., New York 19, N. Y.
*Associate Editor:* Gilbert P. Smith, 430 West 116th St., New York, N. Y.
Next Meeting: Wykagyl Country Club, Westchester, N. Y., June 3, 1960.

### THE SOUTHEASTERN ACADEMY OF PROSTHODONTICS

*President:* Walter A. Hall, Jr., P. O. Box 115, Loyola University, New Orleans, La.
*President-Elect:* E. C. Kelly Geiger, 7550 Biscayne Blvd., Miami Beach, Fla.
*Vice President:* William L. McCracken, School of Dentistry, University of Alabama, Birmingham, Ala.
*Secretary-Treasurer:* John H. Allgood, 516 Military Road, Columbus, Miss.